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# The perceptions of Iowa farmers toward integrated pest management, and, Beauveria bassiana (Balsamo) Vuillemin in the corn ecosystem: its effect on Coleomegilla maculata DeGeer

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The perceptions of Iowa
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and
*Beauveria bassiana* (Balsamo) Vuillemin in the corn
ecosystem--Its effect on *Coleomegilla maculata* DeGeer

by

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# CHAPTER I. INTRODUCTION

Agricultural producers are searching for resource-efficient, lower-cost, and more profitable farming systems. Sustainable agriculture provides possible alternatives for these farmers, and it is gaining national attention, while having significant impact on the future direction of research and education. A great deal of confusion exists, however, about the concept of sustainable agriculture (Francis et al., 1988). Clarifying the concept often involves "low input" , suggesting that one key strategy contained in this concept is to reduce off-farm chemicals and fertilizers to minimum necessary levels. Related to this strategy is a more efficient and less destructive management of the farm resources.

A critical component of sustainable agriculture is integrated pest management (IPM). It has been suggested that sustainable agriculture can be viewed as a broadening of IPM programs that have been developed over the past 20 years (Francis et al., 1988). IPM is defined as "a holistic approach to pest control that uses combined means to reduce the status of pests to tolerable levels while maintaining a quality environment" (Pedigo, 1984).

There are several key points to this definition. First, the objective of any IPM program is protecting the marketable product, not merely killing the pest. In most cases, some damage to the commodity may occur, and "complete freedom from insect attack is neither necessary in most cases, nor is it appropriate for insect pest management" (Luckmann and Metcalf, 1982). This approach implies human tolerance when living and cultivating crops in the presence of pest species. Pests should be viewed as beneficial organisms in agricultural production systems. The occurence of a relatively few species in agroecosystems actually favors the development of pest problems and agricultural system instability (Bird, 1987).

A second important point is the increased emphasis on environmental protection--reducing the contamination and degradation of our natural resources. This can be accomplished by reducing the reliance on chemical pesticides as the sole control alternative and by reducing the amount of those chemicals applied, or by eliminating their use completely.

Deemphasizing chemical controls stems not only from environmental concerns, but from the development of pesticide resistant populations of pests. In some cases, there are few chemicals that are still effective or the increased number of applications necessary for control has led to decreased profitability (Metcalf, 1982). IPM proposes that pest management must view pests as a part of a whole production system. This entails study of the biology and population dynamics of the pest, the interaction among pests and beneficial organisms and the environment, and the effect of cultural practices on the pest. In most cases, several control tactics need to be utilized to manage pest problems. The alternative control measures can be divided into five broad categories: cultural, chemical, mechanical, genetic, and biological.

The use of biological organisms is viewed as environmentally safe; it preserves endangered species and biological diversity. DeBach (1964) defined biological control as " the action of parasites, predators, or pathogens in maintaining another organism's population density at a lower average than would occur in their absence." A1987 National Academy of Sciences report (reported in Klassen, 1987) stated that "biological control can and should become the primary method used in the U.S. to ensure the health and productivity of important plant and animal species--development of biological control as the foundation of pest management is the important challenge we have in making safe and efficient use of our managed ecosystems.

Interest in biological control has led to research to develop different techniques for expanding the concepts of integrated pest management. One of the major thrusts has been to develop microbial controls which have been defined as "including all aspects of the utilization of microorganisms or their by-products in the control of insect pest species" (Maddox, 1982). As a component of IPM systems, insect pathogens can be used in at least three different ways: 1) by maximum utilization of naturally occurring diseases, 2) by the introduction of insect pathogens into insect pest populations as permanent mortality factors, and 3) by the application of insect pathogens as microbial insecticides for temporary control of an insect pest.

This thesis consists of two parts: in Part I (Chapters I to VI) grower perceptions of the general concepts of IPM were identified and analyzed; and in Part II (Chapters I and VII) the compatibility of the fungus, *Beauveria bassiana* , with a predator, *Coleomegilla maculata* was investigated.

## Rationale - Part I

The real effectiveness of any microbial, combination of control tactics, or component of a sustainable system is dependent on it actually being utilized by agriculturalists. Integrated pest management has been studied and promoted for the last 40 years. Studies have demonstrated that when IPM is used costs are lower or the same, net returns are greater, and risk (measured by variability in net return) is the same or lower when compared with conventional control (Rajotte et al., 1986). Despite its economic advantages, IPM has still not been accepted or implemented by many growers, and the difference in the willingness of farmers to adopt IPM is well recognized (Wearing, 1988).

A major obstacle to IPM implementation is the lack of knowledge of IPM developers about the users' attitudes and perceptions (Lambur et al., 1985; Reichelderfer & Bottrell, 1985; Lawson & Dienelt, 1990). Similar implementation problems exist with biological control: van Lenteren (1988) wrote that "the main limitation on the development of biological control is not the research, because natural enemies are easier found and with much lower investment than new chemical pesticides, but rather the attitudes held by the growers."

The present grower perceptions must be identified and understood for several reasons. The individual's perception of pest problems or sources of information may bias his/her interpretation of these inputs or may limit or enhance the type of information that will be sought out, accepted, and believed (Lawson, 1982). The rate at which IPM is adopted is dependent on how potential users perceive it, compared to the current pest control strategy (Grieshop et al., 1988). Correcting misinformation or misperceptions is also critical (Corbet, 1981). How farmers perceive pest problems and the alternative control methods available is therefore an important aspect of pest control research, particularly in determining how advisors can improve the information and guidance they give.

## Purpose and Objectives of the Study - Part I

The purpose of the study was to identify and analyze the perceptions of Iowa farmers toward integrated pest management and various key components inherent to its concept and use. The intent of an increased understanding of farmers' present perceptions was to identify its implications for education. The specific objectives were to:

1. Characterize farmers based on pest control methods in use and demographic information.
2. Determine the farmers' familiarity with the terms IPM, biological control, and microbial control.
3. Identify the types of control measures being used by farmers.
4. Ascertain if differences exist in perceptions based on characteristics of the farmer, farm, and pest control practices in use.

## Operational Definitions

The following terms are defined to provide clarity in understanding this part of the research:

Perception - a manner of acting, feeling, or thinking that shows one's disposition or opinion.

Integrated pest management - a holistic approach to pest control that uses combined means to reduce the status of pests to tolerable levels while maintaining a quality environment.

Biological control - the action of parasites, predators, or pathogens in maintaining another organism's population density at a lower average than would occur in their absence.

Microbial control - includes all aspects of the utilization of microorganisms or their by-products in the control of insect pests.

Crop pest - any organism (weed, disease, insect) that competes with humankind for food or fiber.

Pesticide - broad spectrum chemicals used to kill pests.

Rationale - Part II

Corn, *Zea mays* Linnaeus (Cyperales: Graminae), is attacked by a complex of insects from the time it is planted until it is utilized for feed or food. One of the most important corn pests in North America is the European corn borer, *Ostrinia nubilalis* (Hübner) (Lepidoptera: Pyralidae). The entomopathogenic fungus, *Beauveria bassiana* (Balsamo) Vuillemin (Deuteromycotina: Hyphomycetes), is an effective control agent of *O. nubilalis* (Marcandier and Riba, 1986; Lewis and Cossentine, 1986; Bing, 1990). It also has been proven effective against the Colorado potato beetle, *Leptinotarsa decemlineata* (Say) (Campbell et al., 1980; Anderson et al., 1988); the chinch bug, *Blissus leucopterus leucopterus* (Say) (Ramoska, 1984); the corn earworm, *Helicoverpa zea* (Boddie) (Cheung and Grula, 1982); and the pecan weevil, *Curculio caryae* (Horn) (Champlin et al.,1981) among others. *Beauveria bassiana* has been produced commercially as Boverin® in eastern Europe and the Soviet Union, and in the future could possibly be used commercially over extensive areas in the United States.

In viewing the effects of any microbial on non-target species, there are two divergent perspectives representing the hypothetical extremes (Bailey, 1971). There are those that believe that because microbials occur naturally without harmful effects to non-target organisms, little evaluation of their impact is needed. The other view is that because some of these insect pathogens are able to persist and replicate in nature, they should require stricter evaluation.

Literature on the interaction between pathogens and non-target organisms shows the mortality by a variety of entomogenous fungi was low and almost never exceeded 10% (Flexner et al.,1986). The lowest mortality occurred in those insects inoculated by contact, while greater than 10% mortality occurred in those which consumed the fungal spores. Kiselek (1975) reported 50% of the coccinelled larvae, *Cryptolaemus mortrouzieri* Mulsant, died when they consumed mealy bugs sprayed with a 1% a.i. solution of Boverin: this solution was harmless to adult beetles (reported in Flexner et al.,1986). This could be an important factor if large areas are sprayed resulting in contamination of the beetle's food sources.

Mortality of overwintering coccinellids from *B. bassiana* has been shown. In England, overwintering mortality of *Adalia bipunctata* (Linnaeus) was 35% and *B. bassiana* was the primary cause of death (Mills, 1981). In southeastern France, infection rates reached 50% in overwintering *Coccinella septempunctata* Linnaeus (Hodek, 1973) .

In general, the effect of fungi on natural enemies has not been well studied. Also, many authors extol the specificity of pathogens and rarely discuss their possible broad spectrum activity. This neglect may foster complacency (Bailey, 1971). Each of these two extremes in philosophy regarding interaction of pathogen and beneficial organisms probably have some merit. Some microbials are possibly safer than others and have fewer side effects, while others could cause mortality on non-target organisms--at least this possibility exists to warrant research in this area.

## Objectives - Part II

The study was designed (1) to determine mortality caused by an isolate of *B. bassiana* in a coccinellid predator, *C. maculata* ; and under differing tillage practices, (2) to determine the natural occurrence of *B. bassiana* in the soil and on corn plants, and (3) to monitor the *C. maculata* population.

# CHAPTER II. REVIEW OF LITERATURE

The purpose of the study was to identify and analyze the perceptions of Iowa farmers toward Integrated Pest Management and various key components inherent to its concept and use. The intent of an increased understanding of farmers' present perceptions was to identify its implications for education.

IPM has been defined as a holistic approach to pest management that uses combined means to reduce the status of pests to tolerable levels while maintaining a quality environment. In general, the definition points to a basic change in the philosophy, or the intent of pest management, that goes beyond a mere recipe for action to control pests. Specifically, several implications, relating to the concept of IPM, are contained in its definition. A variety of control tactics can be utililized to decrease the reliance on non-selective methods of suppression to avoid negative effects in the environment (for example, the destruction by broad spectrum insecticides of the natural controls--predators, parasites, and pathogens-- present in the farming ecosystem). Pedigo (1984) stated that the objective of IPM is to manage pests, not solely to kill them, to protect the marketable product. Certainly a possible control option available is the practice of withholding treatment (Corbet, 1981). This suggests that humans are able to tolerate the presence of pests at noneconomic levels, and that controls are employed when pest populations reach levels that cause economic damage (see Pedigo et al., 1986, for an indepth discussion of the "economics" of pest management). Therefore, the use of IPM involves a process in which decisions have to be made concerning what pest management tactics are used and when and if they are used.

Norton (1976b) recognized four elements of a farmer's pest control decision: 1) the perception of pest hazard; 2) the range of available protection measures available; 3) the estimated cost and effectiveness of these measures; and 4) the objectives or decision rules employed by the farmer.

These four elements will be used to organize the literature review of the perceptions or attitudes of farmers toward pest management.

A perception is defined by Webster's New World dictionary as, "the understanding or knowledge, gotten by perceiving or a specific concept, idea, or impression so formed." An attitude is defined as, "a manner of acting, feeling or thinking that shows one's disposition or opinion." Although there may be a difference between their meanings, they have been used interchangeably in the literature, and the words are used similarly for this literature review.

## Pest Control Decisions - A View of Perceptions

Mumford (1982) suggested, following Norton's four elements, a decision model in which choice depends on the perceptions of pest hazard and the net effect of the controls that the person is aware of and able to use. The controls selected are based on their perceived ability to satisfy the farmer's goals. Mumford also wrote that "perceptions arise from direct experience and indirect information on a subject, often filtered in the mind to produce a consistent view on a subject."

Mumford (1981) found that when farmers have had direct experience with a pest problem their estimate of losses are likely to be quite good. However, the worst possible losses are rare events and may not have been experienced by a farmer. Thus, an individual may have to use an indirect means, such as farm magazines or advertisements, to estimate these losses. This type of information may not be relevant to an individual's specific situation and can contribute to the individual's lack of tolerance and need to protect the crop in all circumstances. With respect toward risk assessment, farmers are generally viewed as risk adverse in that they attempt to reduce variabilty as much as possible (Norton, 1982).

Two general categories of methods of pest control were identified by Norton (1976a): 1) prophylactic or pre-emptive measures which are used without an estimate of the level of pest attack, and 2) scheduled, more flexible measures which can be applied before or during pest attack. Control measures can provide two benefits for the farmer: they should reduce variance in crop revenue and they may also increase the net profit, if applied when needed (Mumford, 1981). The relative importance of reducing variance and increasing the net value can depend on the risk perception of the pest problem. A risk adverse farmer may accept a reduced net value if it were necessary to reduce variance, while a risk neutral farmer may be expected to place more value on increasing the net value.

Farmers with expectations of severe pest attack would also be expected to use prophylactic and more intensive controls, i.e. pesticides. A positive relationship between perception of pest hazard and the action taken in response was reported in Mumford (1981). Turpin and Maxwell (1976) have shown that Indiana farmers who perceive a higher level of pest damage are more likely to use pesticides than those who expect lower damage.

The lack of tolerance of growers toward pests is certainly a product of their perception of risk, but other factors also contribute. Farmers may desire not to have a "dirty" crop or to keep in line with the pest control practices of their neighbors (Norton, 1976a) The farmer's perception of the quality standards of produce imposed by processors, retailers, and consumers may also influence the decision to use a disproportionately greater amount of pesticide and to strive for "zero" pest levels (Corbet, 1981).

The implication should not be made that the use of IPM entails a choice between pesticides and alternative controls. Pesticides are a critical component of IPM (the extent to which this is recognized by farmers is not known), but reliance on a single control should be lessened and the use of pesticides should correspond with a determined level of pests that will cause economic damage.

In viewing IPM as an alternative to prophylactic pesticide treatments, it is important to determine whether farmers are aware of IPM and its component alternatives. Grieshop et al. (1988) asked California tomato growers if they had heard of IPM. Seventy percent of the growers replied that they had; 23% answered no and 7% were not sure. The same question was asked of soybean farmers in Iowa, Indiana, Illinois, Missouri, and Ohio; only forty percent indicated that they had heard of IPM

(Edwards, 1988). Similar questions about farmer awareness of biological and microbial controls were not found in the literature.

There are a variety of factors that affect the decision to shift from one control strategy to another. If a farmer is satisfied with the present control stategy, he/she is unlikely to be receptive to change (Norton, 1982). There is a general resistance to change (Wearing, 1988); pesticides are perceived as relatively cheap, easy to use and effective, but the farmers' perceptions of the advantages may be exaggerated. The cost of pesticides fails to account for all the deleterious social and environmental effects of their misuse. These include decreased stability and future productivity of the farming system, destruction of wildlife and beneficial insects, development of pesticide resistance in the pests, and increased health problems of farm workers and the public; costs due to these negative effects total nearly $1 billion annually (Pimentel, 1982).

Another example of an exaggerated perception was cited by Mumford (1981). He asked sugar beet farmers to estimate the effectiveness of their pesticide program. Three fourths of the farmers believed that the insecticides used prevented at least 90% of the potential loss, when previous research indicated that control better than 50% was unlikely. In reality, since farmers have no untreated areas for comparison, and often spray when pest levels are low, there is no way to check the actual effectiveness. Mumford (1981) believed that this perceived efficiency leads to pesticide use and an unwillingness to try other alternatives.

The complexity of a control strategy can be determined by its time and labor requirements and ease of use. Corbet (1981) stated "it must be kept in mind that crop protection is one of the many preoccupations of crop producers ... and it remains possible that many would fail to allocate sufficient time to implement an IPM program effectively." Prophylactic treatments reduce the amount of time involved in making pest control decisions and they fit in well with other production practices.

Grieshop et al. (1988) suggested that adopters of the IPM program perceived the time required for IPM use more unfavorably relative to other factors--compatability, ease of use, and expense--which were viewed very favorably. Nonadopters perceived the time consumption involved in IPM even less favorably than adopters, although there was no statistical difference between the two groups. Adopters viewed the IPM program as easier to use, more compatible, and less expensive to use than nonadopters, but there was not a significant difference between the two groups for ease of use.

Complexity is seen to be high without direct experience in IPM use (Grieshop et al., 1988). The perceived degree of knowlege required also makes acceptance of more complicated IPM programs difficult (van Lenteren, 1988). But, successful programs have been distinguished by their simplicity, at least as far as their methodology is concerned (Corbet, 1981).

The objectives or decision rules employed by the farmer affect the change process. As long as the goal of agriculture is to increase short-term productivity, growers will encounter strong incentives to continue past practices, making the adoption of integrated control increasingly necessary, but at the same time more difficult to implement (Corbet, 1981). The individualistic nature of farmers can slant their perception of control alternatives in favor of chemicals. Pesticides provide a means for the individual farmer to control pests in spite of negligence by neighbors (Klassen, 1987). Grower concern for the protection of natural enemies and the environment is important for increased IPM use. Tait (1982) found negative attitudes toward the use of pesticides due to environmental and health risks. Pesticide residue problems are already seen as a factor promoting IPM (Perkins, 1980).

The farmer decision to shift to IPM will depend on the development of a simple, effective, and economical IPM alternative. However, some have suggested that the main inhibitor to IPM is the availability of cheap and effective pesticides (Corbet, 1981). Therefore, ultimately the change will depend on how the farmers perceive IPM programs relative to conventional pesticide treatments and their farming production goals.

# CHAPTER III . METHODS AND PROCEDURES

## Purpose and Objectives

The main purpose of the study was to identify and analyze the perceptions of Iowa farmers toward Integrated Pest Management and various key components inherent to its concept and use. The intent of an increased understanding of farmers' present perceptions was to identify its implications for education. The specific objectives were to:

1. Characterize farmers based on pest control methods in use and demographic information.
2. Determine the farmers' familiarity with the terms IPM, biological control, and microbial control.
3. Identify the types of control measures being used by farmers.
4. Ascertain if differences exist in perceptions based on characteristics of the farmer, farm, and pest control practices in use.

## Research Design, Population, and Sample

This study can be classified under the category of descriptive research. Descriptive research is directed at determining the nature of a situation as it exists at the time of a study (Ary et al., 1990). To collect the necessary information on the current perceptions of Iowa farmers toward IPM, a mail questionnaire format was used to survey the proposed population.

The population for the study consisted of farmers from the ninety-nine Iowa counties. A farm operator list was purchased from an agreed-upon (prior to its purchase) not-to-be-named group. From this list, a stratified random sampling of approximately six farmers from each county were selected as the study sample for a total of 600 farmers.

## Instrument Development

The survey instrument was developed by the investigator and it consisted primarily of a closed-question format. A primary concern was to devise an instrument that would provide an indepth look at perceptions of IPM, and in particular three areas of research interest relating to IPM--alternative controls, pesticides, and grower tolerance of pests. Its development was also structured to ensure content validity and consisted of the following steps:

1. Pertinent literature was reviewed relating to IPM, the concept and its use, and past IPM surveys. Through the literature review, two additional areas of research interest were identified: the qualities of IPM as an innovation, i.e. , reliability, complexity, newness, economics, and labor/time requirement; and the decision rules employed by the farmer.
2. A rough draft of perception statements produced from the literature review was examined by a panel of experts-- the faculty members on the research graduate committee and Extension personnel involved in IPM--to provide feedback on the format and the instrument's content and to suggest possible additional statements. A list of 43 statements was initially developed.
3. A final draft was tested for any ambiguites before being sent to the study sample. An IPM meeting for vegetable growers served for this test purpose. Thirty-six growers attending the meeting were asked to complete the survey and offer suggestions on its improvement.
4. From this feedback and from an item analysis (Henerson et al., 1987) of the perception statements, changes were made to correct problems within the questions and eliminate the less effective items. The statements retained contributed most to the difference in responses between favorable and unfavorable respondents toward IPM.

In its final form, Section II of the survey instrument contained 25 perception statements using a five-point Likert scale. Nine of the statements as written were positive and 16 were negative relating to IPM. The descriptors of the scale were as follows: 1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, and 5 = strongly disagree. The scale is a continuum: "neutral" was considered a response of uncertainty of whether respondents agreed or disagreed with each perception statement.

The literature review also contributed to the development of Sections I, III, and IV. Section I contained yes/no responses to questions about farmers' awareness of the the terms IPM, biological control, and microbial control. Each term was accompanied by its definition. Section III began with a series of three questions. The first asked the number of times the farmers checked their fields for the presence of pests. The second and third questions were related to the procedure used when checking fields; whether the farmer, before applying pesticides, scouted and then varied treatments based on different problem areas and whether the farmer, before deciding to treat with a pesticide, sampled and compared the infestation levels with established thresholds. For each, the response alternatives were always, sometimes, occasionally, and never. These questions were followed by a list of pest control measures. The participants were asked whether they regularly, sometimes, or infrequently used the measures. These questions and their format were taken from a previous study survey produced by the Iowa State Extension Service (Padgitt et al., 1990): slight modifications were made for purposes of this study.

Questions associated with the demographic information desired were contained in Section IV. This section included seven questions of the participants relating to their age, number of years farming, and highest level of education completed; the number of acres that are in crops and the number of these acres that are rented; the major crops produced; and whether farm income was supplemented with work off the farm. A copy of the survey instrument is presented in Appendix A .

The questionnaire was accompanied by a cover letter (Appendix A) which stated the purpose of the research and that all information received would be kept strictly confidential. The cover letter also requested the cooperation of the participants to complete and return the survey, and that if they chose not to participate, return the blank form.

The instrument, its cover letter, and a brief description of the proposed research were submitted to the Human Subjects Committee at Iowa State University. The committee reviewed this material and concluded that the rights and welfare of the human subjects were protected (Appendix B).

## Data Collection

A common criticism associated with mailed questionnaires is the low return rate often encountered using this type of format. Two factors that contribute to overcoming this problem are the saliency of the survey, and the persistence of the investigator in form of continued contacts with the nonrespondents (Linsky,1975; Heberlein and Baumgartner, 1978). Present public concern over pesticide residues in foods and the effect of pesticides on ground water quality, the reduction in pesticide alternatives for the farmers due to new government regulations and pesticide resistance, and the new federal initiative to promote sustainable agriculture (Allen and Rajotte, 1990)-- all point to the saliency of this topic. During the process of data collection, an initial mailing of the survey instrument to the entire sample and two follow-up reminders to nonrespondents were sent.

The initial mailing of the survey on April 10, 1991, included a copy of the questionnaire and a cover letter explaining the purpose of the study. Approximately one month later, a follow-up postcard (Appendix A) was sent to nonrespondents. On June 1, 1991, another questionnaire was mailed. This final contact also was accompanied by a cover letter (Appendix A).

Of the initial 600 farmers contacted, a total of 215 responded. Eighty-eight of these chose not to participate in the study by returning the uncompleted survey, while 137 useable questionnaires were returned.

## Analysis of Data

The data were stored in the Iowa State University main frame computer and analyzed using the Statistical Package for Social Sciences (SPSSx). A level of significance of .05 was set a priori for all inferential statistical procedures. The following commands and procedures were used to describe and analyze the information:

1. The procedure FREQUENCIES was used to determine the distributions of the participants' responses on all items except the number of acres in crops and the number of rented acres.
2. The command RECODE was used to change the values on the positive perception statements to allow for the calculation of frequencies, means, and standard deviations for all computed variables.
3. The command COMPUTE produced variables from the recoded responses for an average rating of favorableness from the 25 perception items and selected statement groupings.
3. The procedure DESCRIPTIVES provided the means and standard deviations for all the perception statements.
4. The procedure MEANS TABLES was used to provide means and standard deviations for all perception variables when the respondents were grouped by demographic and current practices variables.
5. The procedure ONEWAY was used to determine if significant differences existed in the perceptions of respondents when grouped by demographics and current practices.

## Limitations of the Study

The major limitation of the study was the low rate of return of the mailed questionnaire: only 137 (22%) of the 600 farmers chose to participate in the study after three mailings. It was estimated to adequately sample the approximately 100,000 Iowa farmers, a sample size of 380 farmers would have been needed (Krejcie and Morgan, 1970). Ideally, even if the desired response rate was obtained, an additional phone contact with the nonrespondents should have been made to check for any response differences between respondents and nonrespondents. Sufficient time and especially funding limited additional contacts.

# CHAPTER IV. FINDINGS

The main purpose of the study was to identify and analyze the perceptions of Iowa farmers toward Integrated Pest Management and several of its components. The intent of an increased understanding of farmers' present perceptions was to identify its implications for education. The specific objectives were to:

1. Characterize farmers based on pest control methods in use and demographic information.
2. Determine the farmers' familiarity with the terms IPM, biological control, and microbial control.
3. Identify the types of control measures being used by farmers.
4. Ascertain if differences exist in perceptions based on characteristics of the farmer, farm, and pest control practices in use.

This chapter presents the findings of the study obtained from the statistical analysis of the data collected. The chapter is divided into the following sections: (1) Demographic Information; (2) Participants' Familiarity with Terms; (3) Current Pest Management Practices; (4) Perceptions of Farmers Relating to IPM; and (5) Comparisons of Perceptions Based on Demographics and Current Practices.

## Demographic Information

This section describes the demographic characteristics of the study's participants. This information was collected to provide a profile of the respondents and to determine if the various demographic factors influence their perceptions of IPM.

Figure 1 represents the distribution of the resondents by age. Of the participants surveyed, 13 (9.50%) were 30 years old or younger, 36 (26.30%) were 31 to 40 years old, 28 (20.40%) were 41 to 50 years old, 32 (23.40%) were 51 to 60 years old, and 28 (20.40%) were 60 years old or older.

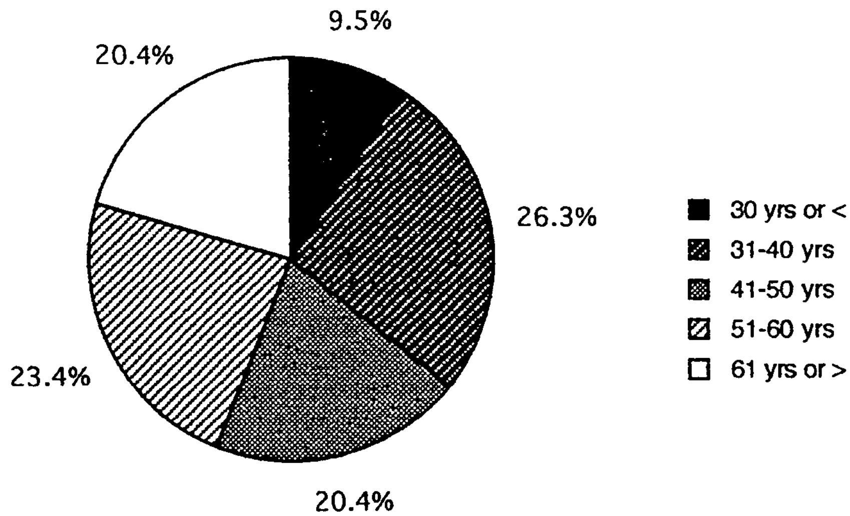


Figure 1. Distibution of participants by age (n=137)

The distribution of respondents by the number of years they had been farming is presented in Figure 2. Nineteen (13.89%) had farmed 10 years or less, 43 ( 31.37%) had farmed 11 to 20 years, 22 (16.08%) had farmed 21 to 30 years, and 53 (38.66%) had been farming for more than 30 years.

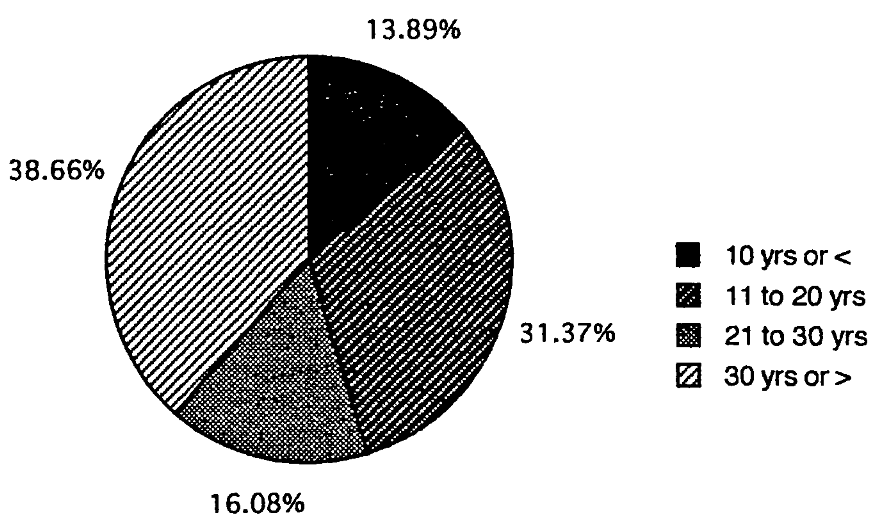


Figure 2. Distribution of participants relating to number of years farming (n=137)

The distribution of the level of education obtained by the participants is represented by Figure 3. Only 8 (5.80%) had less than a high school education, while 67 (48.90%) graduated from high school. Sixty-two respondents continued their education beyond the secondary level: 38 (27.70%) had some college and 24 (17.50%) were college graduates.

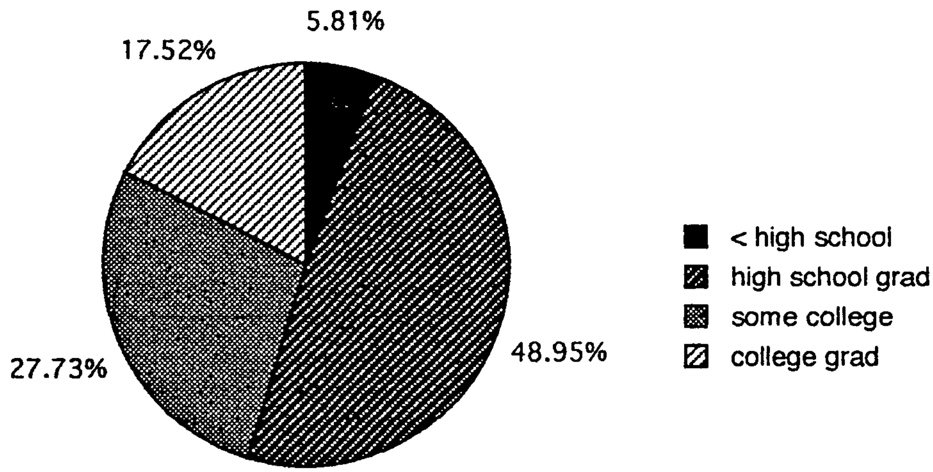


Figure 3. Distribution of participants' level of education (n=137)

The distribution of the major crops grown by the participants is presented in Figure 4: respondents could select as many of the four categories--basic grains, small grains, forage crops, or fruits/vegetables--that applied to their farming operation. Sixty-one (44.53%) of the farmers produced only basic grains; 30 (21.90%) grew basic grains, small grains, and forage crops; 26 (18.98%) produced basic grains and forage crops; and 8 (5.84%) farmed basic and small grains. The " Other " category in Figure 4 represents 10 individuals ( 8.76%): five with forage crops, two with forages and small grains, and one each with vegetables/fruits, basic grains and vegetables/fruits, forages and vegetables/fruits, and with all four.

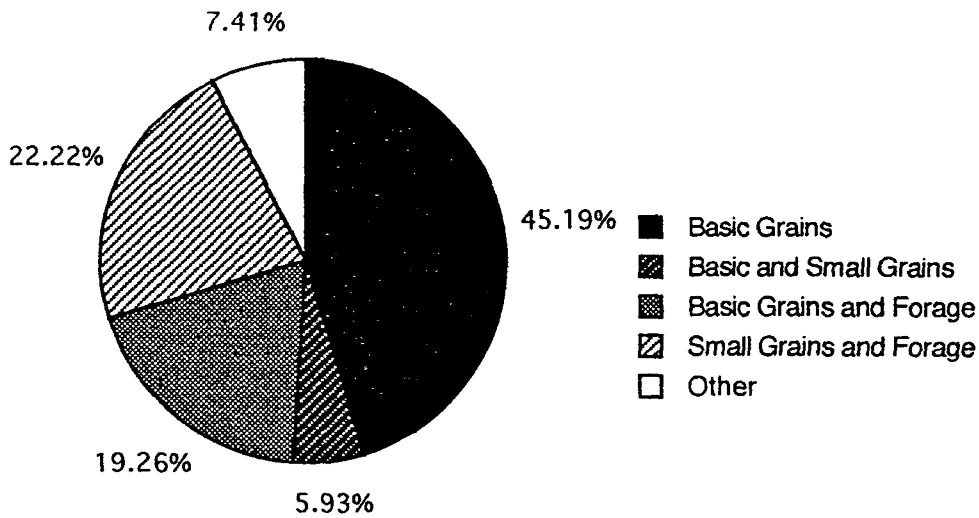


Figure 4. Distribution of the major crops produced on the farm (n=137)

The participants were also asked to provide the number of acres in crop production and the number of these acres that were rented. The average number for each was 403.59 and 224.78 acres, respectively. From these two variables, a third was calculated--the percent of rented crop land. The distribution of this variable is shown in Figure 5. The data indicates that 49 (35.77%) of the farmers rented 25% or less, 26 (18.98%) rented from 26 to 50%, 19 (13.87%) rented from 51 to 75%, and 43 (31.39%) rented from 76 to 100% of their land. However, the larger proportion of respondents in the lowest and highest catagories is misleading due to the large number of farmers who rented no land (40) and those that rented all their land (26).

Participants' Familiarity with Terms

The information in this section was collected to provide an idea of the awareness of farmers of integrated pest management. The study participants were asked if they were familiar with or if they had heard of the terms, IPM, biological control, or microbial control. These three questions produced an answer of " yes" in 106 (77.4%), 117 (85.4%), and 92 (67.2%) of the cases, respectively.

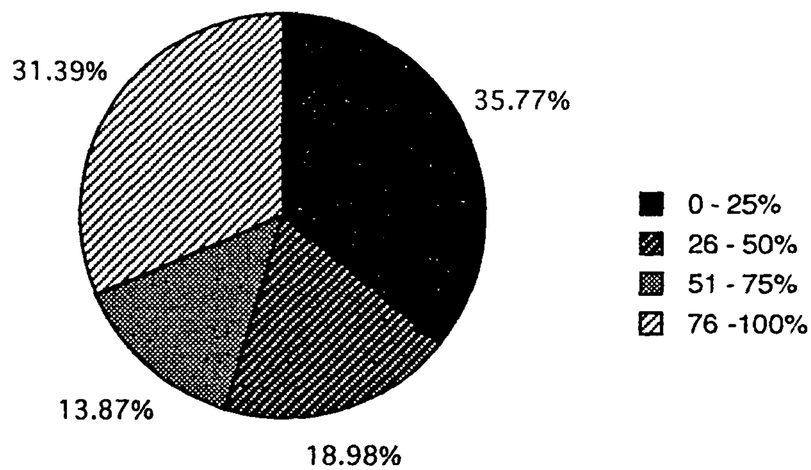


Figure 5. Distribution of percent of total crop land rented (n=135)

## Current Pest Management Practices

The information in this section was gathered to determine the extent to which various pest management practices were being used by farmers.

The distribution of the number of times fields were checked for the presence of crop pests is presented in Figure 6. Only 2 (1.46%) of the respondents never checked their fields while 98 (64.54%) of the participants checked for pests less than six times and 37 (27.01%) checked their fields more than six times per year.

The distribution of the responses to the question, "Before applying pesticides to your fields, do you systematically scout and then vary treatment based upon problems in different areas?", is shown in Figure 7. Fifty-three (39.26%) of the respondents either sometimes or always scouted, 20 (14.81%) scouted occasionally, and nine (6.67%) never scouted.

To the question, "In deciding whether to treat your fields with a pesticide, do you systematically sample and compare the infestation levels with established treatment thresholds?", 50 (37.04%) responded "always", 45 (33.33%) responded "sometimes", 22 (16.30%) responded "occasionally", and 18 responded "never." This information is illustrated in Figure 8. Of those that always sampled, 20 (40%) checked their fields more than six times per year, 17 (34%) checked their fields from 4-6 times, and 13 (26%) checked their fields from 1-3 times for pests.

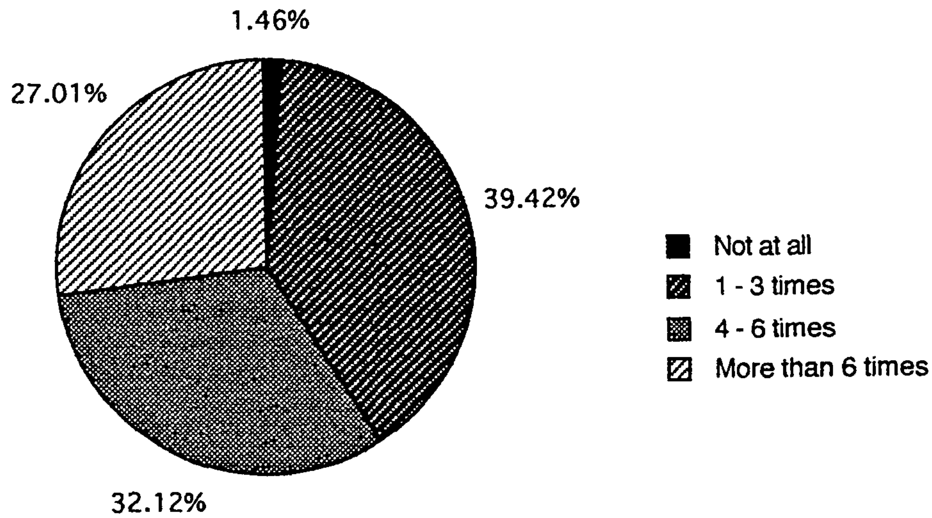


Figure 6. Distribution of how many times per year fields are checked for presence of pests (n=137)

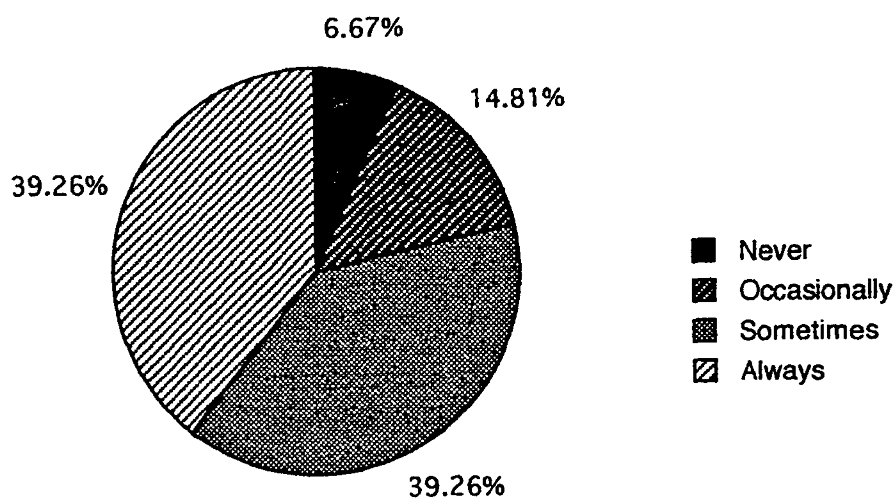


Figure 7. Distribution of whether fields are scouted and then pesticide treatments are varied based on pest problems found (n=135)

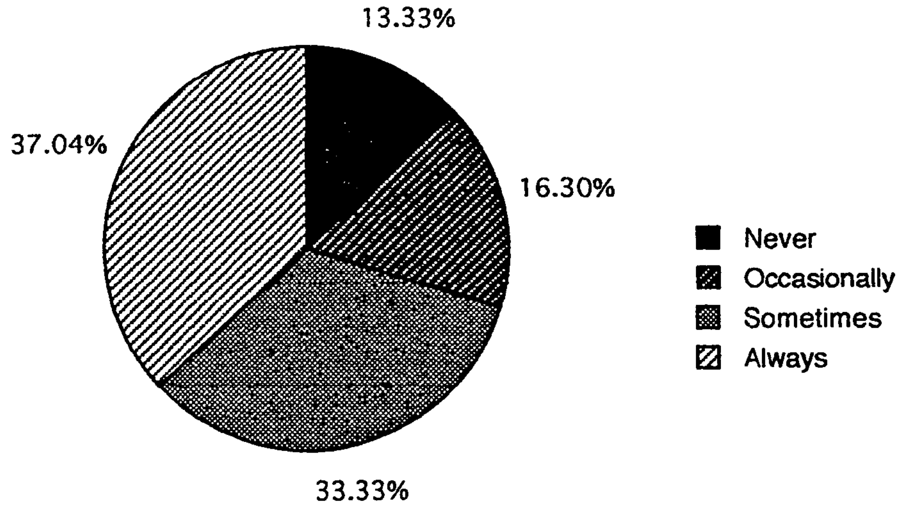


Figure 8. Distribution of those farmers who systematically sample and compare infestation levels before treating fields with a pesticide (n=135)

The participants were asked to identify which pest control they use and whether they regularly, sometimes or infrequently used them. The list of control practices included seven alternatives; space was provided for those practices used by the participants, but not contained in the list. Their responses are summarized in Table 1. Crop rotation was used most regularly with 105 (75.2%) respondents citing its use. It was followed by tillage, plant resistant varieties, and pesticides which were regularly used by 80 (58.4%), 51 (37.2%), and 48 (35.0%) respondents, respectively. Adjustments in planting time was used regularly by only 22 (16.1%) respondents, but its sometimes use (39.4 %) was similar to pesticides (43.8%) and plant resistant varieties (40.9%). Hiring a crop consultant and using a microbial insecticide were the least frequently used practices: 104 (75.9%) never or infrequently used a consultant and 126 (88.9%) never or infrequently used a microbial insecticide. None of the 137 participants responded with an alternative practice not contained in the list.

Table 1. Percentages of the practices used by respondents to control pests (n=137)

| Control Practice | Regularly | Sometimes | Infrequently/Never |
|---|---|---|---|
| Crop rotation | 75.2% | 19.0% | 5.1% |
| Tillage | 58.4% | 27.7% | 13.2% |
| Pest resistant varieties | 37.2% | 40.9% | 21.2% |
| Chemical pesticide application | 35.0% | 43.8% | 20.9% |
| Adjustments in planting time | 16.1% | 39.4% | 43.8% |
| Hire crop consultant to assist in making pest control decisions | 7.3% | 15.3% | 75.9% |
| Use microbial insecticides such as Dipel® or Thuricide® | 1.5% | 5.8% | 88.9% |

Perceptions of Farmers Relating to IPM

This section presents the study participants' perceptions relating to IPM. The respondents were asked to rate, using a five-point Likert scale, their level of agreement with 25 statements. The descriptors of the scale were as follows: 1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, and 5 = strongly disagree. The composite mean rating for the 25 statements was 2.84. A rank order of the individual statement means with their standard deviations relating to the level of agreement of the participants is shown in Table 2.

The highest mean level of agreement was found on the statement, "Protection of the environment is a critical element of deciding whether to spray or not to spray for pests." The statement, "It is acceptable to have low levels of crop pests present in the field or orchard," was the second highest rated item. These were followed by the statements, "The use of IPM requires more labor than conventional methods," and "Chemical control provides a means for the individual farmer to control pests independent of the actions of neighbors." The statement that received the lowest mean level of agreement was, "Chemical control remains the only reliable method for controlling pests." The second lowest rated item was, "Non-chemical control measures are as effective as chemical control." "It is always necessary to treat against some insect pest in the field or orchard" and "There is enough IPM information to consider its use," followed as the third and fourth lowest statements on level of agreement. The 17 remaining items ranged from 2.57 to 3.14 on level agreement with the statements.

The 25 perception statements consisted of 16 negative and nine positive items regarding IPM. The responses on the positive statements were recoded, with 1=5, 2=4, 3=3, 4=2, and 5=1, thus providing values on a scale of favorableness for negative and positive items: a five was considered very favorable and a one was considered very unfavorable. The composite mean value of favorableness for the perception statements was 3.01 with a relatively small standard deviation (.33). This indicates that in general the respondents were ambivalent toward IPM. Nonetheless, participant means ranged from 1.48 to 3.72. Table 3 presents a rank order of means relating to the favorableness of the responses on each item toward IPM.

"Protection of the environment" and "It is acceptable to have low levels of crop pests," retained the highest and second highest mean values. The third highest rated item of favorableness toward IPM was, "Chemical control remains the only reliable method for controlling pests." The fourth and fifth rated statements were, "IPM methods reduce the risk of crop damage caused by pests" and "It is always necessary to treat against some insect pests." The lowest rated item was, "The use of IPM methods requires more labor." The second lowest rated statement was, "Chemical control provides for control independent of the actions of neighbors." "Pesticides reduce the amount of time that has to be devoted to pest control," ranked third lowest. The fourth lowest ranked position was shared by, "Non-chemical control methods are as effective as chemical control" and "Seeing dead pests tells me that the pest control method I used was effective." The remaining 15 items were rated between the means of 3.27 and 2.64.

Table 2. Rank order of means with their standard deviations relating to the level of agreement of participants with statement regarding IPM[a]

| Rank | Item | n | Mean | S.D. |
|---|---|---|---|---|
| 1 | Protection of the environment is a critical element of deciding whether to spray or not to spray for pests. | 137 | 2.04[b] | 0.80 |
| 2 | It is acceptable to have low levels of crop pests present in the field/orchard. | 136 | 2.12 | 0.66 |
| 3 | The use of IPM methods requires more labor than conventional methods. | 136 | 2.41 | 0.79 |
| 4 | Chemical control provides a means for the individual farmer to control pests independent of the actions of neighbors. | 136 | 2.47 | 0.83 |
| 5 | Pesticide applications reduce the amount of time that has to be devoted to pest control. | 136 | 2.57 | 0.92 |
| 6 | Seeing dead pests tells me that the pest control method I used was effective. | 135 | 2.58 | 0.87 |
| 7 | IPM methods reduce the risk of crop damage caused by pests. | 134 | 2.60 | 0.84 |
| 8 | Killing pests is the major goal of any pest control strategy. | 137 | 2.64 | 1.14 |
| 9 | IPM is a new alternative pest control strategy. | 137 | 2.72 | 0.91 |
| 10 | IPM is a viable alternative for crop protection due to the increased financial gain from its use. | 135 | 2.73 | 0.72 |
| 11 | The consumer market dictates the pest control alternatives that can be used by growers. | 137 | 2.76 | 0.90 |
| 12 | Beneficial organisms are able to keep pests at levels so low that no serious crop damage can occur. | 135 | 2.81 | 0.83 |
| 13 | Pesticides are a critical component of IPM programs. | 135 | 2.82 | 0.85 |
| 14 | An alternative pest control method has to be considerably cheaper than pesticides before I would consider its use. | 137 | 2.87 | 1.00 |
| 15 | The use of pesticides prevents at least 90% of potential loss due to crop pests. | 137 | 2.92 | 0.94 |
| 16 | The use of IPM methods leads to higher variation in yield. | 137 | 2.93 | 0.83 |
| 17 | The net returns from IPM use are greater than from conventional control methods (chemical pesticides). | 135 | 2.95 | 0.68 |
| 18 | Increased crop production is my most important farming goal. | 137 | 3.03 | 1.12 |
| 19 | It is more important to consider the worst possible losses than to consider normal losses when deciding on a pesticide application. | 136 | 3.11 | 0.98 |
| 20 | IPM methods are very complicated to use. | 134 | 3.11 | 0.72 |
| 20 | Microbial controls can harm warm-blooded animals (people, cattle, etc.). | 132 | 3.14 | 0.71 |
| 22 | There is enough IPM information available to consider its use. | 136 | 3.33 | 0.92 |
| 23 | It is always necessary to treat against some insect pest in field/orchard. | 137 | 3.39 | 1.06 |
| 24 | Non-chemical control measures are as effective as chemical control. | 135 | 3.42 | 0.79 |
| 25 | Chemical control remains the only reliable method for controlling pests. | 136 | 3.43 | 0.95 |

[a] Scale: 1= Strongly agree; 2=Agree; 3=Neutral; 4=Disagree; 5=Strongly disagree.
[b] Composite mean for all items=2.87

Table 3. Rank order of means with their standard deviatons relating to the favorableness of participants' responses toward IPM[a]

| Rank | Item | n | Mean | S.D. |
|---|---|---|---|---|
| 1 | Protection of the environment is a critical element of deciding whether to spray or not to spray for pests. | 137 | 3.96[b] | 0.80 |
| 2 | It is acceptable to have low levels of crop pests present in the field/orchard. | 136 | 3.88 | 0.66 |
| 3 | Chemical control remains the only reliable method for controlling pests. | 136 | 3.43 | 0.95 |
| 4 | IPM methods reduce the risk of crop damage caused by pests. | 134 | 3.40 | 0.84 |
| 5 | It is always necessary to treat against some insect pest in the field/orchard. | 137 | 3.39 | 1.06 |
| 6 | IPM is a viable alternative for crop protection due to the increased financial gain from its use. | 135 | 3.27 | 0.72 |
| 7 | Beneficial organisms are able to keep pests at levels so low that no serious crop damage can occur. | 135 | 3.19 | 0.83 |
| 8 | Pesticides are a critical component of IPM programs. | 135 | 3.18 | 0.85 |
| 9 | Microbial controls can harm warm-blooded animals (people, cattle, etc.). | 132 | 3.14 | 0.71 |
| 10 | IPM methods are very complicated to use. | 134 | 3.11 | 0.72 |
| 10 | It is more important to consider the worst possible losses than to consider normal losses when deciding on a pesticide application. | 136 | 3.11 | 0.98 |
| 12 | The net returns from IPM use are greater than from conventional control methods (chemical pesticides). | 135 | 3.05 | 0.68 |
| 13 | Increased crop production is my most important farming goal. | 137 | 3.03 | 1.12 |
| 14 | The use of IPM methods leads to higher variation in yield. | 137 | 2.93 | 0.83 |
| 15 | The use of pesticides prevents at least 90% of potential loss due to crop pests. | 137 | 2.92 | 0.94 |
| 16 | An alternative pest control method has to be considerably cheaper than pesticides before I would consider its use. | 137 | 2.87 | 1.00 |
| 17 | The consumer market dictates the pest control alternatives that can be used by growers. | 137 | 2.76 | 0.90 |
| 18 | IPM is a new alternative pest control strategy. | 137 | 2.72 | 0.91 |
| 19 | There is enough IPM information available to consider its use. | 136 | 2.67 | 0.92 |
| 20 | Killing pests is the major goal of any pest control strategy. | 137 | 2.64 | 1.14 |
| 21 | Seeing dead pests tells me that the pest control method I used was effective. | 135 | 2.58 | 0.87 |
| 21 | Non-chemical control measures are as effective as chemical control. | 135 | 2.58 | 0.79 |
| 23 | Pesticide applications reduce the amount of time that has to be devoted to pest control. | 136 | 2.57 | 0.92 |
| 24 | Chemical control provides a means for the individual farmer to control pests independent of the actions of neighbors. | 136 | 2.47 | 0.83 |
| 25 | The use of IPM methods requires more labor than conventional methods. | 136 | 2.41 | 0.79 |

[a] Scale: 1=Very unfavorable; 2=Unfavorable; 3=Neutral; 4=Favorable; 5=Very favorable.
[b] Composite mean for all items=3.01

Table 4 represents the distribution of responses of the participants to the perception statements; the statements are ordered as in Table 3. Seven of the 15 statements rated in favorableness between the means of 3.27 and 2.64 were dominated by the "neutral" category which contains the largest percent of respondents. The statements producing the most "neutrals" were: "Microbial controls can harm warm-blooded animals," with 82 (59.9%) respondents; "Net returns from IPM are greater than from conventional control methods," with 78 (56.9%) respondents; and "IPM methods are very complicated to use," with 72 (52.6%) respondents. Of the 10 statements that ranked highest and lowest on favorableness, only the item, "Alternatives are as effective as chemicals," produced a conspicious number of unsure respondents of 55 (40.1%).

Mean values of favorableness were also determined for selected groupings of perception statements. The categories included perception items related to pest management alternatives, tolerance of pests/risk assessment, and pesticides. The means calculated were 2.87, 3.26, and 2.86, respectively. Table 5 presents the component means for each category in descending order and the frequencies of responses of each statement. This information, when compared with the mean for all items (3.01), indicated the participants' responses were relatively more favorable toward IPM for statements related to tolerance of pests and risk assessment than for statements regarding pest management alternatives and pesticides.

Three of the four statements within the tolerance/risk category produced relatively favorable mean values. The statement, "Low levels of crop pests are acceptable," contributed most to the favorable perception toward IPM based on tolerance: 74.5% of the respondents agreed with the statement. The percentage of repondents (56.9%) disagreeing with the item, "It is always necessary to treat," also added greatly to a favorable perception. The statement contributing to an unfavorable perception relating to tolerance was, "Killing pests is a major goal," with 56.9% of the respondents agreeing or strongly agreeing to it. All statements produced relatively low percentages of neutral

Table 4. Distribution of responses of participants on perception statements

| Statement | SA[a] | A | N | D | SD |
|---|---|---|---|---|---|
| Protection of the environment is a critical | 21.9[b] | 59.1 | 12.4 | 5.8 | 0.7 |
| Low levels of crop pests are acceptable | 9.5 | 74.5 | 10.2 | 4.4 | 0.7 |
| Chemical control is the only reliable method | 2.2 | 17.5 | 22.6 | 48.9 | 8.0 |
| IPM reduces risk of crop damage | 4.4 | 47.4 | 29.2 | 16.1 | 0.7 |
| It is always necessary to treat | 4.4 | 23.4 | 8.0 | 56.9 | 7.3 |
| Increased financial gain from IPM use | 2.2 | 35.0 | 49.6 | 10.9 | 0.7 |
| Pesticides are a critical component of IPM | 2.9 | 35.0 | 39.4 | 19.0 | 2.2 |
| Beneficial organisms keep pests at low levels | 1.5 | 38.0 | 40.1 | 16.1 | 3.0 |
| Microbial controls can cause harm | 0.7 | 12.4 | 59.9 | 19.7 | 3.6 |
| More important to consider the worst losses | 0.7 | 35.0 | 21.2 | 37.2 | 5.1 |
| IPM methods are complicated | 0.7 | 16.8 | 52.6 | 26.6 | 1.5 |
| Net returns are greater from IPM | 0.7 | 22.6 | 56.9 | 17.5 | 0.7 |
| Increased crop production is primary goal | 8.8 | 29.2 | 18.2 | 38.0 | 5.8 |
| IPM leads to higher yield variation | 1.5 | 30.7 | 43.8 | 21.2 | 2.9 |
| Pesticides prevents 90% of loss | 2.9 | 36.5 | 29.2 | 28.5 | 2.9 |
| Alternative control must be cheaper | 6.6 | 34.3 | 27.7 | 28.5 | 2.9 |
| The consumer market dictates pest control | 2.2 | 46.0 | 28.5 | 20.4 | 2.9 |
| IPM is a new pest control strategy | 4.4 | 43.1 | 30.7 | 19.7 | 2.2 |
| There is enough IPM information available | 0.7 | 22.6 | 24.8 | 45.3 | 5.8 |
| Killing pests is the major goal | 15.3 | 41.6 | 9.5 | 31.4 | 2.2 |
| Dead pests show effectiveness | 5.1 | 51.1 | 22.6 | 19.7 | 1.5 |
| Alternatives are as effective as chemicals | 0.7 | 10.2 | 40.1 | 41.6 | 5.8 |
| Pesticides reduce the amount of time | 5.1 | 55.5 | 17.5 | 19.7 | 1.5 |
| Chemical control provides independence | 2.9 | 64.2 | 16.1 | 14.6 | 1.5 |
| IPM methods mean more labor | 7.3 | 54.7 | 27.0 | 9.5 | 0.7 |

[a] Scale: 1= Strongly agree; 2=Agree; 3=Neutral; 4=Disagree; 5=Strongly disagree.
[b] Values given in percentages.

Table 5. Means and distribution of responses for perception statement categories--alternatives, tolerance/risk, and pesticides

| Statement | Mean | SA[a] | A | N | D | SD |
|---|---|---|---|---|---|---|
| Alternatives | | | | | | |
| Beneficial organisms keep pests at low levels | 3.18 | 1.5[b] | 38.0 | 40.1 | 16.1 | 3.0 |
| Microbial controls can cause harm | 3.14 | 0.7 | 12.4 | 59.9 | 19.7 | 3.6 |
| Alternative control must be cheaper | 2.87 | 6.6 | 34.3 | 27.7 | 28.5 | 2.9 |
| Alternatives are as effective as chemicals | 2.58 | 0.7 | 10.2 | 40.1 | 41.6 | 5.8 |
| Dead pests show effectiveness | 2.58 | 5.1 | 51.1 | 22.6 | 19.7 | 1.5 |
| Tolerance/Risk | | | | | | |
| Low levels of crop pests are acceptable | 3.88 | 9.5 | 74.5 | 10.2 | 4.4 | 0.7 |
| It is always necessary to treat | 3.39 | 4.4 | 23.4 | 8.0 | 56.9 | 7.3 |
| More important to consider the worst losses | 3.11 | 0.7 | 35.0 | 21.2 | 37.2 | 5.1 |
| Killing pests is the major goal | 2.64 | 15.3 | 41.6 | 9.5 | 31.4 | 2.2 |
| Pesticides | | | | | | |
| Chemical control is the only reliable method | 3.43 | 2.2 | 17.5 | 22.6 | 48.9 | 8.0 |
| Pesticides prevents 90% of loss | 2.92 | 2.9 | 36.5 | 29.2 | 28.5 | 2.9 |
| Pesticides reduce the amount of time | 2.57 | 5.1 | 55.5 | 17.5 | 19.7 | 1.5 |
| Chemical control provides independence | 2.47 | 2.9 | 64.2 | 16.1 | 14.6 | 1.5 |

[a] Scale: 1= Strongly agree; 2=Agree; 3=Neutral; 4=Disagree; 5=Strongly disagree.
[b] Values given in percentages.

responses that ranged from 8% for "Low levels of crop pests are acceptable" to 21.2% for "More important to consider the worst possible losses."

On the other hand, the alternative category was characterized by high percentages of neutral responses ranging from 22.6% for the statement, "Dead pests show effectiveness, " to 59.9% for the statement, "Microbials can cause harm." The statements, "Dead pests show effectiveness" and "Alternatives are as effective as chemicals, "contributed to the less favorable perception toward IPM for the category: both statements showed the same mean of 2.58.

Within the pesticide category, responses to the statements, "Chemical control provides independence" and "Pesticides reduce the amount of time, "produced mean values of 2.47and 2.57. The majority of participants were in agreement with these statements, 64.2 and 55.5% respectively, and thus contributed to the lower mean of favorableness toward IPM for the category. The participants' responses to "Chemical control is the only reliable method" indicated disagreement with the item and produced the only favorable mean (3.43) within the category. Eight percent strongly disagreed and 48.9% disagreed, while slightly less than one fifth of the respondents were in agreement with the statement. A somewhat unrealistic perception of the effectiveness of pesticides was indicated by the responses to "Pesticides prevent 90% of loss"; only 31.4 % of the respondents expressed disagreement.

The means and distribution of responses of the other 12 perception statements are presented in couplets of related items or singly in Table 6. The items are related to the qualities of IPM ,i.e. , reliability, complexity, newness, economics, and labor/time requirement; and the decision rules employed by the farmer. The means, 3.27 and 3.05,of the items, "Increased financial gain from IPM use" and "Net returns are greater from IPM, " indicated a favorable perception of IPM, but both were distinguished by a large percentage of neutral responses (49.6 and 56.9%). Responses varied on the two items concerned with the risk involved in IPM use. When directly stated, "IPM reduces risk of crop damage,"more than one half of the respondents were in agreement; but when less directly stated, "IPM leads to higher yield variation, "less than one fourth were in disagreement with the statement.

In general, the respondents perceived IPM as a new pest management stategy with 4.4% strongly agreeing and 43.1% agreeing; 30.7% of the respondents were neutral. While 37.9% of the participants were in agreement that pesticides are a critical component of IPM, an equal percentage (39.4) was unsure, and 20.4% of the respondents disagreed.

Table 6. Means and distribution of responses for statements relating to IPM and farmer goals

| Statement | Mean | SA[a] | A | N | D | SD |
|---|---|---|---|---|---|---|
| Increased financial gain from IPM use | 3.27 | 2.2[b] | 35.0 | 49.6 | 10.9 | 0.7 |
| Net returns are greater from IPM | 3.05 | 0.7 | 22.6 | 56.9 | 17.5 | 0.7 |
| IPM reduces risk of crop damage | 3.40 | 4.4 | 47.4 | 29.2 | 16.1 | 0.7 |
| IPM leads to higher yield variation | 2.93 | 1.5 | 30.7 | 43.8 | 21.2 | 2.9 |
| IPM is a new pest control strategy | 2.72 | 4.4 | 43.1 | 30.7 | 19.7 | 2.2 |
| Pesticides are a critical component of IPM | 3.19 | 2.9 | 35.0 | 39.4 | 19.0 | 2.2 |
| IPM methods are complicated | 3.11 | 0.7 | 16.8 | 52.6 | 26.6 | 1.5 |
| IPM methods mean more labor | 2.41 | 7.3 | 54.7 | 27.0 | 9.5 | 0.7 |
| There is enough IPM information available | 2.67 | 0.7 | 22.6 | 24.8 | 45.3 | 5.8 |
| Protection of the environment is a critical | 3.96 | 21.9 | 59.1 | 12.4 | 5.8 | 0.7 |
| Increased crop production is primary goal | 3.03 | 8.8 | 29.2 | 18.2 | 38.0 | 5.8 |
| The consumer market dictates pest control | 2.76 | 2.2 | 46.0 | 28.5 | 20.4 | 2.9 |

[a] Scale: 1= Strongly agree; 2=Agree; 3=Neutral; 4=Disagree; 5=Strongly disagree
[b] Values given in percentages.

To the statement, "IPM methods are very complicated," almost one third of the respondents were in disagreement, but there was a large percentage (52.6) of partcipants who were undecided. The participants were more definite on their perception of the labor requirement with IPM: 54.7% agreed with the statement, while 9.5% disagreed.

Slightly more than 50% of the respondents perceived a lack of IPM information, 24.8% were neutral, and only 22.6% agreed there was enough information available to consider its use.

The participants expressed their perception of the importance of the environment as a consideration in deciding whether to chemically control a pest. Over one fifth (21.9%)of the respondents strongly agreed and 59.1% agreed. Responses to the traditional farming goal of increased crop production were equally divided: 39% of the respondents were in agreement and 43.8% of the respondents were in disagreement. Participant responses indicated the consumer market dictates the pest control alternatives that can be used by the growers (less than one fourth of the respondents disagreed) and therefore suggested a farmer compliance with with market standards.

## Comparisons of Perceptions

This section presents the trends indicated by comparisons of the perception responses by groups within selected demographic and current practices variables. The independent variables selected were the age of the participants, the number of years they had been farming, the highest level of education completed, the percent of crop acres rented, and the regularity with which sampling was used as a pest management decision-making tool. The group values compared within each variable were measures of average favorableness toward IPM for all perception items and those items relating to alternatives, tolerance, and pesticides. Analysis of variance (ANOVA) indicated significant statistical differences among means, and a Scheffé post hoc test determined where the differences existed. An alpha of .05 was set prior to making the tests.

A summary of ANOVA for the perception statements based on the age of the respondents is presented in Table 7. The means for the five groupings suggested a trend for decreasing favorableness with increasing age for all items, for alternatives, and for tolerance, and significant differences among groups within the statement categories are indicated. A Scheffé test detected a significant difference between the means of group 2 (3.13) and group 4 (2.88) for all items and between the means of group 2 (3.51) and group 5 (3.02) for tolerance. There were no significant statistical differences among the group means for pesticides.

Table 7. Analysis of variance of perception statement categories by groupings of age

| Perception statement categories | Group 1 Mean S.D. n | Group 2 Mean S.D. n | Group 3 Mean S.D. n | Group 4 Mean S.D. n | Group 5 [a] Mean S.D. n | F-ratio | F-prob. |
|---|---|---|---|---|---|---|---|
| All items | 3.14 | 3.13 | 3.01 | 2.88 | 2.93 | 3.44* | 0.010 |
| | 0.26 | 0.31 | 0.42 | 0.30 | 0.26 | | |
| | 13 | 36 | 28 | 32 | 28 | | |
| Alternatives | 3.06 | 3.03 | 2.81 | 2.73 | 2.78 | 3.08* | 0.018 |
| | 0.49 | 0.42 | 0.47 | 0.38 | 0.39 | | |
| | 13 | 35 | 28 | 29 | 28 | | |
| Tolerance/ Risk | 3.21 | 3.51 | 3.34 | 3.13 | 3.02 | 3.14* | 0.017 |
| | 0.44 | 0.52 | 0.52 | 0.59 | 0.56 | | |
| | 13 | 36 | 28 | 31 | 27 | | |
| Pesticides | 2.94 | 3.02 | 2.83 | 2.69 | 2.82 | 1.44 | 0.233 |
| | 0.49 | 0.57 | 0.75 | 0.53 | 0.54 | | |
| | 13 | 36 | 28 | 31 | 26 | | |

[a]Group 1 = 30 years or less; Group 2 = 31 to 40 years; Group 3 = 41 to 50 years; Group 4 = 51 to 60 years; Group 5 = 61 years or older.

* Significant at .05 level.

A similar trend was indicated by the four group means of number of years the respondents had farmed--favorableness decreased with increased farming experience. Although the trend was suggested by the group means for all of the statement categories, ANOVA only showed significant statistical differences between farming experience and the perception statements relating to all items and to alternatives, as seen in Table 8. Differences in perceptions between means for group 2 (3.12) and group 4 (2.91) for all items and between group 1 (3.08) and group 4 (2.74) for alternatives were revealed by Scheffé post hoc tests.

Table 8. Analysis of variance of perception statement categories based on the number of years respondents had farmed

| Perception statement categories | Group 1 Mean S.D. n | Group 2 Mean S.D. n | Group 3 Mean S.D. n | Group 4 [a] Mean S.D. n | F-ratio | F-prob. |
|---|---|---|---|---|---|---|
| All Items | 3.10 | 3.12 | 2.93 | 2.91 | 4.40* | 0.006 |
| | 0.28 | 0.31 | 0.46 | 0.27 | | |
| | 19 | 43 | 22 | 53 | | |
| Alternatives | 3.08 | 2.93 | 2.87 | 2.74 | 3.41* | 0.020 |
| | 0.46 | 0.41 | 0.50 | 0.40 | | |
| | 19 | 42 | 21 | 49 | | |
| Tolerance/ Risk | 3.27 | 3.46 | 3.14 | 3.14 | 2.54 | 0.060 |
| | 0.48 | 0.57 | 0.72 | 0.59 | | |
| | 19 | 43 | 21 | 52 | | |
| Pesticides | 2.97 | 2.97 | 2.82 | 2.74 | 1.41 | 0.243 |
| | 0.55 | 0.55 | 0.72 | 0.58 | | |
| | 19 | 43 | 21 | 51 | | |

[a]Group 1 = 10 years or less; Group 2 = 11 to 20 years; Group 3 = 21 to 30 years; Group 4 = 31 years or more.
* Significant at .05 level.

Analysis of variance indicated significant differences based upon the level of education completed by the participants and their responses to perception categories for all items, alternatives and tolerance. This information and the group means presented in Table 9, suggested that with more education, favorableness towards IPM increased. Post hoc tests revealed significant differences in the means for all items between group 2 (2.94) and group 4 (3.16) and for alternatives between group 2 (3.16) and group 4 (3.57). The pesticide group means failed to suggest any significant trend.

Table 9. Analysis of variance of perception statement categories based on level of education completed

| Perception statement categories | Group 1 Mean S.D. n | Group 2 Mean S.D. n | Group 3 Mean S.D. n | Group 4 [a] Mean S.D. n | F-ratio | F-prob. |
|---|---|---|---|---|---|---|
| All Items | 2.97 | 2.94 | 3.04 | 3.16 | 2.93* | 0.036 |
| | 0.43 | 0.29 | 0.27 | 0.45 | | |
| | 8 | 67 | 38 | 24 | | |
| Alternatives | 2.68 | 2.79 | 2.92 | 3.08 | 3.14* | 0.028 |
| | 0.38 | 0.41 | 0.44 | 0.48 | | |
| | 7 | 64 | 36 | 24 | | |
| Tolerance/ Risk | 3.16 | 3.10 | 3.38 | 3.57 | 4.60* | 0.004 |
| | 1.04 | 0.53 | 0.41 | 0.74 | | |
| | 8 | 66 | 37 | 24 | | |
| Pesticides | 3.00 | 2.78 | 2.93 | 2.92 | 0.84 | 0.473 |
| | 0.64 | 0.55 | 0.61 | 0.67 | | |
| | 7 | 66 | 37 | 24 | | |

[a]Group 1 ; Less than high school; Group 2 = High school graduate; Group 3 = Some college; Group 4 = College graduate.
* Significant at .05 level.

The group means of the perception statement categories suggested a trend for increased favorableness with an increased percentage of rented land, as shown in Table 10. ANOVA indicated a significant statistical difference among groups for all items and for alternatives. Scheffé post hoc tests revealed significant differences among the means of groups 1 (2.89) and 2 (2.94) and group 4 (3.17) for all items and between group 1 (2.75) and group 4 (3.06) for alternatives.

Table 10. Analysis of variance of perception statement categories based on the percent of crop acres rented

| Perception statement categories | Group 1 Mean S.D. n | Group 2 Mean S.D. n | Group 3 Mean S.D. n | Group 4 [a] Mean S.D. n | F-ratio | F-prob. |
|---|---|---|---|---|---|---|
| All Items | 2.89 | 2.94 | 3.04 | 3.17 | 6.86* | 0.000 |
| | 0.26 | 0.43 | 0.29 | 0.30 | | |
| | 49 | 26 | 19 | 43 | | |
| Alternatives | 2.75 | 2.78 | 2.87 | 3.06 | 4.45* | 0.005 |
| | 0.44 | 0.46 | 0.37 | 0. 40 | | |
| | 44 | 26 | 19 | 42 | | |
| Tolerance/ | 3.19 | 3.11 | 3.28 | 3.43 | 1.94 | 0.127 |
| Risk | 0.60 | 0.72 | 0.53 | 0.54 | | |
| | 47 | 26 | 19 | 43 | | |
| Pesticides | 2.76 | 2.74 | 2.86 | 3.05 | 2.25 | 0.085 |
| | 0.56 | 0.68 | 0.70 | 0.49 | | |
| | 46 | 26 | 19 | 43 | | |

[a]Group 1 = 0 to 25%; Group 2 = 26 to 50%; Group 3 = 51 to 75%; Group 4 = 76 to100%.

* Significant at .05 level.

Comparisons of the means of the perception statement categories of the frequency of use of sampling suggested a trend for all categories. The results of analysis of variance procedures (Table 11) showed significant differences among the group means for all items, for alternatives, and for pesticides. Scheffé tests indicated significant differences between the means of group 1 (3.11) and group 4 (2.80) for all items, between the means of group 1 (3.01) and group 4 (2.63) for alternatives, and between the means of group 1 (3.02) and group 3 (2.57) for pesticides.

Table 11. Analysis of variance of perception statement categories based on the prevalence of the use of sampling

| Perception statement categories | Group 1 Mean S.D. n | Group 2 Mean S.D. n | Group 3 Mean S.D. n | Group 4 [a] Mean S.D. n | F-ratio | F-prob. |
|---|---|---|---|---|---|---|
| All Items | 3.11 | 3.01 | 2.92 | 2.80 | 4.55* | 0.005 |
| | 0.33 | 0.31 | 0.24 | 0.40 | | |
| | 50 | 45 | 22 | 18 | | |
| Alternatives | 3.01 | 2.86 | 2.77 | 2.63 | 3.98* | 0.010 |
| | 0.42 | 0.41 | 0.44 | 0.46 | | |
| | 48 | 42 | 21 | 18 | | |
| Tolerance/ Risk | 3.36 | 3.26 | 3.19 | 2.97 | 1.87 | 0.138 |
| | 0.52 | 0.60 | 0.54 | 0.78 | | |
| | 49 | 44 | 22 | 18 | | |
| Pesticides | 3.02 | 2.88 | 2.57 | 2.67 | 3.56* | 0.016 |
| | 0.58 | 0.59 | 0.48 | 0.67 | | |
| | 49 | 44 | 22 | 17 | | |

[a]Group 1 = Always; Group 2 = Sometimes; Group 3 = Occasionally; Group 4 = Never.
* Significant at .05 level.

# CHAPTER V. DISCUSSION AND IMPLICATIONS

The main purpose of the study was to identify and analyze the perceptions of Iowa farmers toward Integrated Pest Management and various key components inherent to its concept and use. The study's intent was to increase understanding of perceptions and to relate the findings to their educational implications.

## Discussion of Perceptions

Based on the findings, farmers can be characterized as being older (64% were older than 41 years old), having more than 21 years of farming experience (55%), and educated--only 6% did not graduate from high school and 45% had at least some continuing education past high school. The average number of acres in crops per farm was approximately 400 acres with half of the acres rented. These results are comparable with Iowa farmer survey findings of Padgitt et al. (1990) and Bruening (1989).

These personal and farm characteristics have been recognized as important in explaining the farmer's decision-making process in adopting a new technology (Rodgers, 1983). It is generally found that farmers who are younger, better educated, and operate larger farms are most likely to use a new technology. Although the research on behavior is far from conclusive, it can be assumed that if an attitude is favorable, it will lead to a change in behavior (Lambur et al., 1985). Conversely, there is growing evidence that adoption of new technologies does not always reflect positive assessments or psychological acceptance (Lasley and Bultena, 1988). Thus, the link between a farmer's perception of a new technology and its adoption is not clearly understood. This study's findings of farmer perceptions of IPM provided additional insight into the interaction between perception and use of a new technolgy based on farm and farmer characteristics and current control practices.

Nearly 50% of the farmers perceived IPM as a new pest control strategy. Their perceptions of this new technology showed a trend for increased favorableness toward IPM for farmers who are younger, who had farmed for fewer years, and who had more education. Their perceptions toward IPM, alternative pest controls and tolerance of pests based on these same farmer characteristics showed a similar trend, while no such trend was noted for their perceptions of the conventional control, e.g., pesticides. A possible implication of these findings was perceptions of nontraditional concepts or practices may be more easily changed through continuing education than perceptions of established practices. It is also possible that continuing education is reinforcing established practices.

Contrary to the belief that age, size of farm holdings, and education are important predictors of farmers' opinions about new technology, Grieshop et al. (1988) found that they did not affect the decision-making process with IPM. But, land ownership was found to affect the process; only 6% of the adopters did not own land, while 31% of nonadopters did not own land. In the present study, land ownership was analyzed differently as the percentage of crop acres rented. It was found that an increasing percent of rented crop acres can be a predictor of a favorable perception of IPM and alternative pest controls.

Iowa farmers, as indicated by the findings of this study, used other control measures besides pesticides: 75% of the respondents regularly rotated their crops, almost 60% used tillage practices, and 20% infrequently or never used pesticides. Almost 80% of the respondents indicated fields were always or sometimes scouted and then pesticide treatments were varied based on the pest problems found. The real measure of whether farmers were using IPM was revealed by those farmers who were sampling pests and comparing infestation levels with established treatment thresholds to determine if control treatments were necessary. Thirty-seven percent of the study participants said they always sampled, but only 40% of these stated they checked their fields more than six times per year. Padgitt et al. (1990) found a similar pattern and concluded that farmers may have perceived themselves as practicing IPM, but they were actually sampling with less intensity than was required.

Maybe farmers maintain a false or unrealistic view of their sampling practices, but it is possible perceptions have been changed prior to or after the decision to sample has been made. Grieshop et al. (1988) found that previous experience with IPM affected the decision-making process and that a successful previous experience led to satisfied customers. This present study's findings indicated a trend for increasing favorableness of perceptions toward alternatives and IPM with increasing frequency of sampling use. Respondents also viewed pesticides less favorably with increasing sampling use. This is particularly interesting in light of growing evidence that adoption of new technologies does not always reflect positive perceptions.

How farmers perceive alternative controls in relation to pesticides was of particular interest for this study. In general, Iowa farmers were aware of possible alternatives: 85%, 77%, and 67% of the farmers had heard of or were familiar with biological control, IPM, and microbial control, respectively. Farmers remained fairly satisfied with pesticides: they were in agreement that pesticides provide independence and reduce labor and somewhat less in agreement that pesticides were very effective. Over 60% of the farmers surveyed were uncertain or disagreed that pesticides were a critical component of IPM. If farmers are satisfied with pesticides, as the study suggested, this could lead to rejection of IPM. However, they were also in agreement that pesticides were not the only reliable control available. Farmers' perceptions of alternatives were somewhat inconsistent with this favorable perception.

On one hand, farmers who had an opinion agreed that beneficial organisms can keep pests at levels that serious crop damage does not occur. On the other hand, they viewed alternatives as less effective than pesticides. This inconsistency can be explained by nature of the term, alternatives: some may be viewed as effective, but in general, alternatives were perceived as less effective. This possibly led to uncertainty: 40% of the respondents were neutral toward this statement. Farmers were, however, in agreement that being able to see dead pests shows the effectiveness of the control method. This perception can limit the use of alternative controls, such as microbial pesticides, which lack the quick killing power of chemical pesticides, and microbial insecticides were found to be the least used (89% never or infrequently used) alternative in this study.

IPM was also evaluated by farmers for its complexity and labor requirements, if there was enough information on IPM to consider its use, and possible financial gain and risk involved in its use. Farmers were generally ambivalent about whether or not IPM methods were very complicated to use. There was, however, agreement that the use of IPM means more labor which is consistent with findings of Grieshop et al. (1988). Concern has been expressed that IPM does not offer a short-term advantage in profits compared to conventional control, particularly because of the cost of labor (Stockdale, 1980). Forty percent of the farmers agreed that an alternative control must be considerably cheaper than pesticides before its use would be considered, possibly due to the perceived labor involved. Farmers in the study were unsure of the economic advantages of IPM, although there is documented evidence of short-term benefits (Rajotte et al., 1986). Recent literature (Fenemore and Norton, 1985) indicated that economic advantage alone is insufficient to promote IPM because it is tied to the farmer's perception of risk. Generally, farmers' perception of risk reduction through IPM was favorable, still one third were undecided and almost 44% were unsure whether IPM leads to higher yield variation. In conclusion, Iowa farmers' perceptions of the relative advantages of IPM were characterized by uncertainty, and their disagreement that there was enough IPM information to consider its use served to accentuate this point.

Farmer tolerance of pests was a positive finding of this study. In general, farmers agreed that low levels of crop pests were acceptable and disagreed that it was always necessary to treat against some insect pest. These perceptions are not only important to reduce pesticide use, but also influence the use of alternative controls. They are particularly favorable for the use of biological control because low levels of crop pests are necessary to maintain populations of beneficial organisms.

Farmers' goals are an important aspect of the decision-making process. A series of statewide (Iowa) surveys indicated farmers were becoming more concerned with the environmental problems associated with conventional agricultural practices (Lasley and Bultena, 1988). This concern, related to pest management, was also expressed by the participants in this study: farmers strongly agreed protection of the environment was a critical consideration when deciding to use or not to use pesticides. Unfortunately, 57% of farmers perceived killing pests as the major goal of any pest control strategy. This is in direct conflict with the philosophy of IPM--protection of the marketable product is of utmost importance, not killing the pest, while maintaining environmental quality. Other goals such as increasing crop production and meeting market standards can also negate environmental concern and increase pesticide use.

Corbet (1981) stated "as long as the goal of agriculture is first and foremost to increase short-term productivity, many growers will encounter strong incentives to continue (past) practices." Farmers, in this study, slightly disagreed that increased production was their primary goal. While not the primary goal, it is possible this slight disagreement suggested that it remained a decision goal of some significance. Meeting market quality standards was viewed as a determining factor of the type of pest control used by farmers: almost 50% of the farmers expressed agreement with this perception.

The conclusions drawn from this discussion of farmer perceptions were in large part unfavorable to implementation of IPM. Farmers continued to be satisfied with pesticides based on their effectiveness, ease of use, and independence they afford the farmer. Farmers were also uncertain about the advantages of IPM and alternative controls; the one factor they were definite about was IPM requires more labor. On the favorable side, farmers expressed that environmental effects were an important consideration when deciding whether to use a pesticide. Farmers also indicated a tolerance for pests: low levels of pests in their fields were viewed as acceptible and they did not feel the need to always treat for pests. These positive aspects were offset by other decision rules held by the farmers, i.e., to increase short-term productivity, to kill pests, and to satisfy market standards.

## Educational Implications

Haskell et al. (1979) wrote that "the biggest basic problem in the introduction of innovative techniques (of pest control) has been the tendency to ignore the socio-cultural factors involved." Understanding these factors helps to explain how and why farmers choose to use, modify, or reject new alternatives. Specifically, an understanding of the farmers' perceptions helps to identify and define real problems so that advisors, extensionists, educators, etc., can improve the information and guidance they give.

A research study, conducted by Headley (1978), surveyed a U.S. panel of agricultural experts in research and extension to obtain estimates of the probable importance of the various pest control techniques over the next 15 years. Their conclusions were chemicals would continue to be of major importance and biological methods would remain of minor importance. The previous discussion of farmer perceptions indicated a similar pattern for the future. In general, farmers were uncertain about IPM and they remain satisfied with pesticides; misconceptions and farmer objectives were held that are counter to the basic philosophy of IPM. These conclusions were not unexpected.

Lambur et al. (1985) cited the complex nature of IPM when compared with the unilateral use of pesticides as an obstacle to its broad acceptance and use, and they provided the following example. Their study was related to the adoption of differing control strategies, from 1965-1985, in control of mites in apple orchards: after five years in the 60's, the first control promoted (a miticide) was used by almost 60% of the growers; the third method promoted (IPM), after five years in the 80's, was used by almost 30% of the growers. But, the complexity of IPM is just one of the major obstacles to its implementation cited in the literature.

In a survey of consultants, research entomologists, and extension entomologists, three social-marketing obstacles--grower satisfaction with pesticides, lack of grower confidence, and a general resistance to change--matched complexity in importance (Wearing, 1988). The conclusions of the present study served to reinforce the existence of these barriers, and indicated if implementation of IPM is to occur on a large scale, a more intensive promotional campaign will be required.

Lawson and Dienelt (1990) suggested to change these attitudes may require marketing IPM just like chemical companies market pesticides. Other researchers have suggested specific ways to modify and stengthen education and extension.

Because the basic barriers to implementation of IPM can be characterized as a lack of confidence, knowledge, and experience, van Lenteren (1988) suggested the only way to overcome them is to install demonstrations on commercial farms to show the potential of IPM. A finding of the present study, that farmers who always sampled for crop pests had a more favorable perception of IPM and a less favorable perception of pesticides, supported this suggestion. But, increased farmer involvement will be required at all levels of IPM implementation.

Francis et al. (1988) wrote the research-extension system is characterized by the "top down" model of setting priorities and searching for alternatives and as problems in agriculture become more complex the model becomes less valuable. They suggested that producers, extension agents/specialists, and researchers need to work as a team to bring in more ideas and broaden the ownership in the search for alternatives. More farmer involvement and the broadening of ownership are principles that have been promoted in developing countries by U.S. agencies. It is surprising, to this researcher, that they have not been promoted more strongly in our country.

These suggestions are especially important considering the present financial situation of Iowa State University Extension: one of refocusing and plans of living without some 12% of its annual state appropriation. Robert Anderson, ISU's vice provost for extension, explained "what we need to do is decide what is the core of extension, what is our mission, what are the programs that are central, which programs are peripheral and generally speaking we want to deliberately focus our activity" (Ames Daily Tribune, October 8, 1991). The question remains, are the public and policy makers/funders really interested in making the needed changes to implement IPM on a larger scale?

# VI. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The purpose of the study was to identify and assess the perceptions of Iowa farmers toward Integrated Pest Management and various key components inherent to its concept and use. The specific objectives were to: (1) characterize the farmers based on present pest control practices and demographic information; (2) determine the farmers' familiarity of the terms IPM, biological control, and microbial control; (3) identify the types of control measures being used by farmers; and (4) ascertain if differences exist in perceptions based on characteristics of the farmer, farm, and pest control practices in use. This chapter is presented in five sections: (1) Summary of Procedures; (2) Summary of Findings; (3) Conclusions; (4) Recommendations; and (5) Recommendations for Future Research.

## Summary of Procedures

To collect the necessary information on the current perceptions of Iowa farmers toward IPM, a mail questionnaire format was used to survey Iowa farmers. A stratified random sampling of farmers by county was used to select the study sample.

The survey questionnaire was developed for this study and was based on previous research and writings related to IPM and perceptions. It contained a section of 25 perception statements using a five-point Likert scale (1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, and 5 = strongly disagree). These statements were developed from a more extensive list through a process of review by a panel of experts and a field-test by growers. The questionnaire also contained sections on farmer awareness of IPM, biological control, and microbial control; current pest control practices; and farmer and farm characteristics. The survey questionnaire was initially mailed to 600 farmers; an additonal two follow-up contacts were made to increase the return rate.

One hundred and thirty-seven usable questionnaires were returned during the data collection period of April 20th to June 20th, 1991. The responses were summarized and analyzed using descriptive and inferential statistical procedures.

## Summary of Findings

A review of the findings of the study produced the following summary:

1. Iowa farmers in this study can be characterized as skewed toward the older age groups (64% were older than 41 years old), having more than 21 years of farming experience (55%), and educated--only 6% did not graduate from high school and 45% had at least some continuing education past high school. The average number of acres in crops per farm was approximately 400 acres with half of the acres rented.
2. Nearly 50% of the farmers perceived IPM as a new pest control strategy.
3. Their perceptions of this new technology showed a trend for increased favorableness toward IPM for farmers who were younger, who had farmed for fewer years, and who had more education. Their perceptions toward IPM, alternative pest controls and tolerance of pests based on these same farmer characteristics showed a similar trend, while no such trend was noted for their perceptions of the conventional control--pesticides. Inceasing percent of rented lands can also be a predictor of favorable perceptions of IPM and alternatives.
4. Farmers are aware of possible alternatives: 85%, 77%, and 67% of the farmers had heard of or were familiar with biological control, IPM, and microbial control, respectively.
5. Iowa farmers used other control measures besides pesticides: 75% of the respondents regularly rotated their crops, almost 60% used tillage practices, and 20% infrequently or never used pesticides. Almost 80% indicated fields were always or sometimes scouted and then pesticide treatments were varied based on the pest problems found. Thirty-seven percent of the study participants said they always sampled and compared infestation levels with established treatment thresholds, but only 40% of these stated they checked their

fields more than six times per year. Eighty-nine percent never or infrequently used microbial pesticides.

6. A trend was noted for increasing favorableness of perceptions toward alternatives and IPM with increasing frequency of sampling use. Respondents also viewed pesticides less favorably with increasing sampling use.
7. Mean values of favorableness toward IPM were determined for the selected groupings--alternatives, tolerance of pests/risk assessment, and pesticides--of perception statements. The means calculated were 2.87, 3.26, and 2.86, respectively. These means when compared with the mean for all items (3.01), indicated the participants' responses were relatively more favorable toward IPM for statements related to tolerance of pests and risk assessment than for statements regarding pest management alternatives and pesticides.
8. Over 50% of the farmers disagreed there was enough IPM information available to consider its use; over 60% were uncertain or disagreed that pesticides are an integral component of IPM.
9. Farmers were generally ambivalent (53% neutral) about whether IPM methods were very complicated to use. There was agreement(62% strongly agreed or agreed) that the use of IPM means more labor. Generally, farmers' perception of risk reduction through IPM was favorable, still one third were undecided and almost 44% were unsure whether IPM leads to higher yield variation. Over 50% of the farmers were unsure of the IPM economic advantage.
10. Twenty-two percent strongly agreed and 60% of the farmers agreed that protection of the environment was a critical consideration when deciding to use or not to use pesticides. Farmers slightly disagreed that increased production was their primary goal. Meeting market quality standards was viewed as a determining factor of the type of pest control used by farmers: almost 50% of the farmers expressed agreement with this perception. Fifty-seven percent of the farmers perceived killing pests as the major goal of any pest control strategy.

## Conclusions

The following conclusions were drawn from the findings of the study:

1. The farmer and farm characteristics (age, number of years farming, education, and percent of crop land rented) and the pest management practice of sampling were predictors of farmer's perceptions of IPM and its components. Farmer frequency of sampling use was also a predictor of farmer's perceptions of pesticides.
2. The majority of Iowa farmers were aware of IPM, biological control, and microbial control.
3. Farmers were satisfied with pesticides based on their effectiveness and ease of use, and the independence they afford the farmer.
4. Iowa farmers were uncertain about advantages of IPM and of alternative controls and did not consider there was enough information available to consider its use.
5. Farmers indicated a degree of tolerance of pests.
6. The objectives or decision rules of Iowa farmers indicated continued reliance on chemical pesticides.

## Recommendations

Based on the findings of the study, the literature review, and the researcher's experience the major recommendation was, to increase the use of IPM on a larger scale, an intensive promotional campaign is required which focuses on increasing the farmers' perceptions of the benefits of IPM. This campaign would include:

1. IPM should be marketed like the pesticide industry markets its products. This approach would include continued sampling of the market (farmers) to understand perceptions of the product (IPM).
2. Increase farmer/extension/research contact by (a) installing demonstration plots on commercial plots to show the potential of IPM, and (b) using a "bottom up" model of setting

priorities and searching for and evaluating alternatives in which farmers, extensionists, and researchers would work as a team.

## Recommendations for Future Research

The following recommendations were made for additional research in the IPM implementation process:

1. A survey of the perceptions of the growing number of farmers/growers involved in alternative crops (vegetables, fruits,trees,etc.) and compare the results with this study.
2. A more indepth study of farmer use of sampling to determine how, how often, and who samples; and if and how the recommended sampling process has been modified by the farmer.

# CHAPTER VII. PART II

This Masters thesis was designed to incorporate two aspects, an educational and a technical, of pest management research, and in doing so, to stress the importance of each in developing future pest management programs. Part I investigated the perceptions of farmers toward IPM and its components. Part II determined the compatibility of two biological control alternatives within IPM; specifically it determined the compatibility of a fungus, *Beauveria bassiana* (Balsamo) Vuillemin, with the insect predator, *Coleomegilla maculata* DeGeer (Coleoptera: Coccinellidae).

## Review of Literature

Beauveria bassiana The first pathogen of an insect identified as truly pathogenic was a fungus. The fungus, *B. bassiana*, was reported in 1835 to be causing mortality in the silkworm, *Bombyx mori* (Linnaeus) (Steinhaus, 1956). *Beauveria bassiana* is a member of one of the two most important groups of entomogenous fungi (Ferron, 1978). It occurs naturally in soil, plant residues, living plant tissue and insects such as the Colorado potato beetle, *Leptinotarsa decemlineata*, and may infect larvae, pupae, or adults (Hare and Andreadis, 1983). In a survey of populations of Iowa corn insects, Brooks and Raun (1965) isolated *B. bassiana* from the northern corn rootworm, *Diabrotica longicornis* (Say); the spotted cucumber beetle, *D. undecimpuctata howardi* Barber, *Glischrochilus quadrisignatus quadrisignatus* (Say), and the European corn borer, *Ostrinia nubilalis*. The fungus has also been isolated from field-collected *O. nubilalis* eggs (Lynch and Lewis, 1978).

Stability and Persistence B. bassiana in the Environment In 1890 *B. bassiana* was used to combat the chinch bug, *Blissus leucopterus leucopterus*. The first two years showed some reduction in pest numbers, but in the following years applications of the fungus were ineffective (Billings and Glenn, 1911). One of the major conclusions of the experience was environmental conditions are key factors in its effectiveness (Cherwonogrodzky, 1980). A variety of abiotic factors--sunlight, temperature, and moisture--influence the stability and persistence of fungi (Lingg and Donaldson, 1981). Conidia of entomophogous fungi are more resistant to sunlight than protozoan spores but less resistant than bacterial spores (Ignoffo et al.,1977).

Entomogeneous fungi are mesophiles; the optimum temperatures for development, pathogenicity, and survival of the pathogen generally falls between 20 to 30°C (Ferron, 1978). Temperature is one of the more important factors influencing spore germination. It regulates the time required for germination and the number of germinating spores in a population, which is directly related to the infection rate in an insect population (Yendol and Hamlen, 1973). Below 0°C, fungal cells generally survive but rarely grow and above 40°C most cells stop growing and die.

Moisture (vapor or liquid) is often cited as the key abiotic factor influencing persistence and germination of fungal spores. Spore germination depends upon the relative humidity (RH): conidia of *B. bassiana* lived longer at RH of 0 or 34% than 75% (Ferron, 1978). Spore germination requires a RH of greater than 95%, however, Ramoska (1984) differentiated between atmospheric and microenvironmental RH's and wrote that the latter, a boundary layer of moisture next to the insect's exoskeleton, could be more important for spore germination.

<u>Virulence of B. bassiana</u> A variety of factors influence the virulence of the *B. bassiana*. Many fungi will only attack a particular life stage; young larval instars are assumed to be more susceptible to infection due to an age-maturation immune response in more mature larvae (McCoy et al., 1988). Feng et al. (1985) found 1st instar *O. nubilalis* to be the most susceptible of the five instars to infection by *B. bassiana*, however, 5th instars were only slightly less susceptible. They hypothesized that length of each stage was the determining factor due to the possibility of casting off fungal spores during molting. Various isolates of *B. bassiana* have also shown a high degree of host specificity (McCoy et al., 1988). But, in virulence tests of five strains of *B. bassiana* on the pecan weevil, *Curculio*

*caryae*, Champlin et al. (1981) found that strains exibiting pathogenicity in the pecan weevil were also capable of infecting the corn earworm, *Helicoperva zea*,and dosage was the factor affecting terminal infection.

Biology of Coccinellidae Relating to the Corn Ecosystem The majority of the species of the Coccinellidae, commonly referred to as lady beetles, are beneficial due to their predaceous behavior. Various researchers have recognized that the predator complex associated with corn may significantly influence populations of *O. nubilalis*. Sparks, et al. (1966) identified eight species of lady beetles that make up a large part of this complex in the North Central States: *Coleomegilla maculata*, *Hippodamia convergens* Guérin-Méneville, *H. tredecipunctata tibialis* (Say), *H. parenthesis* (Say), *Coccinella novemnotata* Herbst, *C. trifasiata* Linnaeus, *Cycloneda munda* (Say), and *Adalia bipunctata*. Their study of this complex's effect on *O. nubilalis* indicated that predators play an important role in this insect's population fluctuation, but cannot be depended upon to be present year after year at any one location. Thus, *O. nubilalis* populations are probably governed by other biotic and environmental factors.

Predation on *O. nubilalis* eggs by lady beetles can also lead to fungal infections developing in the remaining eggs due to type and degree of damage caused. Adult and larval coccinelids attack the eggs at random and consume both the chorion and the egg contents. In those cases where partially devoured egg masses are left by coccinelids, higher rates of fungal infection has occurred than in egg masses damaged from other corn predators, such as *Orius insidiosus* (Say) and *Chrysopa carnea* Stephens (Lynch and Lewis, 1977).

Of the lady beetle species preying on *O. nubilalis* eggs and larvae, *C. maculata* seems to be the most important (Andow and Risch,1985; Andow, 1990). While earlier research had identified *H. convergens*, *H. tredecimpunctata*, and *Coccinella septempunctata* as egg predators, Andow and Risch (1985) found no evidence supporting egg predation by *H. convergens* . Andow (1990) showed that only *C. maculata* adults and larvae readily accepted and consumed *O. nubilalis* egg masses. Also, only larvae of *C. maculata* completed development when consuming *O. nubilalis* egg masses; the others failed to mature beyong the second instar.

*Ostrinia nubilalis*, however, is not the only source of food for *C. maculata* . Aphids and pollen are major sources of food. Hodek(1973) stated that *C. maculata* feeds preferentially on corn pollen. Andow and Risch (1985) reported the greatest increase in *C. maculata* populations is at corn tasseling. Population increases also corresponded with increases in the aphid, *Rhopalosiphum maidis* (Fitch), numbers (Wright and Laing, 1980). The polyphagous nature of this lady beetle contributed to a tendency to disperse less and its greater abundance (Andow and Risch, 1985).

Food preference was identified by Ewert and Chiang (1966) as one of the factors that govern the distribution of coccinellids within the cornfield: *C. maculata* was found lower down on corn plants than other coccinellids due to the presence of corn pollen in the lower leaf axils. Physical factors also contributed to the vertical distribution of the beetles on corn plants. *Hippodamia convergens* was found on the upper parts of the plant due to a greater tolerance to desiccation and its positive photoresponse; *C. maculata* favored the more shaded and humid environment of the lower parts of the plant.

## Statement of Purpose

It was concluded *C. maculata* would have a greater opportunity for contact with and to exist under conditions favorable for the persistence and growth of *B. bassiana* relative to other coccinellids. Coccinellids of 16 genera have shown susceptibility to *B. bassiana* (Goettel et al., 1990). Specifically, laboratory experiments have demonstrated susceptibility of *C. maculata* adults to an isolate of *B. bassiana* ( Magalhaes et al., 1988). Different isolates of the same species have varying degrees of host specificity due to various biotic and abiotic factors (Goettel et al., 1990). The particular isolate of *B. bassiana* was selected for this research because it is highly virulent to *O. nubilalis* and has provided season-long suppression of the corn pest due to its ability to move within the plant (Bing and Lewis, 1991). The purpose of this research was to test the compatiblity of this isolate with *C. maculata* larvae.

## Materials and Methods

The study was designed (1) to determine mortality caused by an isolate of *B. bassiana* of a coccinellid predator, *C. maculata* ; and under differing tillage practices, (2) to determine the natural occurrence of *B. bassiana* in the soil and on corn plants, and (3) to monitor the *C. maculata* population.

The research was conducted in plots maintained under the tillage practices (conventional, chisel, and no-till) for five years at the Iowa State University Research Farm, Ankeny, Iowa. A hybrid corn, Garst 8555®, was planted at 56,000 seeds per hectare on May 28, 1990. Each tillage plot (37.5 x 125 m) was divided into 20 subplots (9 x 25 m).

Field application of *B. bassiana* To expose *C. maculata* larvae to *B. bassiana* under field conditions, the experiment was designed as a randomized complete block. The experiment was conducted twice, on August 8 and August 22, with two and four replications respectively. Treatments consisted of applications of corn grits with or without *B. bassiana* . Each treatment was conducted in 3 m row sites selected from the subplots within the conventional tillage plot. To avoid larval emigration from the treatment sites the following preventative measures were used: 1) aluminum barriers were placed in the soil encircling each site, 2) Fluon® AD-1 (Northern Products, Inc., Woonsocket, RI) was painted on the top 5 cm of the barriers, and 3) plants were trimmed to avoid leaf contact between rows.

Treated corn grits were produced by spraying them with a suspension of an isolate of *B. bassiana* ($1.1 \times 10^8$ conidia/g) (Bing 1990). The *B. bassiana* culture was originally isolated from a field on the Iowa State University Research Farm, Ankeny, Iowa (ARSEF 3113, USDA-ARS Entomopathogenic Fungi Collection, Ithaca, NY). Hand-held inoculators, similar to those used by

Davis and Oswalt (1979), were used to apply 0.4 g of the corn grits at three locations on the lower two-thirds of each plant.

Three 3rd and 4th instars of *C. maculata* were placed on 10 consecutive plants within each treatment site. The larvae were reared from an initial sample collected from overwintering sites in Ames, Iowa. The larvae were collected one and two days after their release, placed individually in vials, and observed daily for three weeks to determine if any mycosis occurred. During the observation period the larvae were fed *O. nubilalis* eggs and kept in a growth chamber at 20°C and 75% RH.

Laboratory application of B. bassiana Third and fourth instars were also exposed to *B. bassiana* in the laboratory. The experiment was conducted on the same dates with the same treatments and experimental design as the field experiment; two replications with 15 larvae and 4 replications with 10 larvae were used, respectively.

Larvae were placed in containers, containing 6 g of corn grits with and without *B. bassiana*, at 20°C and 75% RH. After 24 hrs, the larvae were removed, placed in individual vials, and observed daily for three weeks to determine if any mycosis occurred. The larvae were fed *O. nubilalis* eggs and maintained in a growth chamber at 20°C and 75% RH.

Plant and Soil Sampling Corn plant and soil samples were taken approximately every two weeks in the subplots to be assayed for *B. bassiana*. One plant, within each of the subplots, was randomly selected on each sampling date. The plant was cut just below the soil line and placed in a plastic bag. A 7.5 cm core of soil was taken with a soil auger within the row next to the plant selected and also placed in a bag. After the first sampling date, soil samples were collected in only 10 randomly selected subplots. A total of 100 plants and 60 soil samples were taken from June 6th to August 6

Isolation of *B. bassiana* from Soil and Plants The soil samples were dried and pulverized with mortar and pestle. For each sample, 2.5 g of soil were added to 100 ml of sterile distilled $H_2O$ (10x dilution) and stirred for 30 minutes to form a suspension. A 1 ml sample of the suspended material was pipetted and streaked onto agar plates which favored the growth of *B. bassiana* (Doberski and Tribe, 1980). The plates were allowed to dry at ambient temperatures and then were placed in an incubator at 26$^{o}$C with no light.

The plants were surface sterilized with 95% ethyl alcohol. Tissue was excised from the leaf collar of the lowest five leaves of each plant, placed on the agar, and also incubated at 26$^{o}$C with no light. The presence or absence of *B. bassiana* soil and plant samples was recorded after 14 days.

Beetle Sampling Ten 3 m rows were randomly selected within the subplots and marked by stakes. The average number of plants within each 3 m row varied between conventional, chisel, and no-till plots (16, 15, and 13, respectively). Sampling consisted of collecting *C. maculata* adults and larvae within the sampling site during a period of five minutes. The plots were sampled each week from July 11 to September 4.

## Results

Application of *B. bassiana* Field and laboratory experiments were conducted to determine the effect (mortality) of exposure to *B. bassiana* on 3rd and 4th *C. maculata* instars. Of the 180 larvae released in the treated plots, 152 and 156 larvae were collected respectively and observed for occurence of mycosis. No mycosis developed in any of the 308 larvae during the 21 days of observation (Table 12).

Laboratory exposure consisted of placing 3rd and 4th instars in containers with corn grit treatments similar to the field experiment. Two replications with 15 larvae and 4 replications with 10 larvae were used on the two dates of the experiment. After a 24 hr exposure period, the 140 larvae were observed for occurence of mycosis. No mycosis developed in any of the larvae (Table12).

Table 12. Infection of *C. maculata* larvae exposed to *B. bassiana* under field and laboratory conditions

| Application | Conidia/g | # Exposed | # Infected |
|---|---|---|---|
| Field | $1.1 \times 10^8$ | 152 | 0 |
| | 0 | 156 | 0 |
| Laboratory | $1.1 \times 10^8$ | 70 | 0 |
| | 0 | 70 | 0 |

Presence of *B. bassiana* on Plants and in Soil A total of 100 plants and 60 soil samples were taken from June 6th to August 6th in plots maintained under the differing tillage practices of conservation, chisel, and conventional.

Tissue was excised from the leaf collar of the lowest five leaves of each plant. From only one plant (in conservation plot), was *B. bassiana* isolated on more than one leaf per plant sampled. This percentage varied between plots on sampling dates, with *B. bassiana* being found on more plants in the conservation plot (Table 13). However, the percentage of *B. bassiana* found also varied within plots on differing dates; no trend was noted between plots and throughout the sampling period. No *B. bassiana* was isolated from plants on the two sampling dates after July 9th in any tillage plot.

Twenty soil samples were taken on the first sampling date; the rest consisted of 10 samples per date. *Beauveria bassiana* was found in all plots, with percentages varying from 30 to 80% throughout the sampling period, but no consistent trend was noted between tillage plots and within plots during the period (Table 14).

Table 13. Percent isolation of *B. bassiana* from corn plant samples taken in field plots maintained under differing tillage practices

| Plot | Date Sampled 6/11 | 6/25 | 7/9 | 7/23 | 8/6 |
|---|---|---|---|---|---|
| | % Plant Samples | | | | |
| Conservation | 30[a] | 20 | 33 | 0 | 0 |
| Chisel | 5 | 10 | 0 | 0 | 0 |
| Conventional | 0 | 40 | 20 | 0 | 0 |

[a]Percentage of 20 plants sampled per date.

Table 14. Percent isolation of *B. bassiana* from soil samples taken in field plots maintained under differing tillage practices

| Plot | Date Sampled 6/11 | 6/25 | 7/9 | 7/23 | 8/6 |
|---|---|---|---|---|---|
| | % Soil Samples | | | | |
| Conservation | 65[a] | 50[b] | 33 | 30 | 30 |
| Chisel | 70 | 40 | 80 | 60 | 50 |
| Conventional | 45 | 40 | 60 | 60 | 40 |

[a]Percentage of 20 samples per plot on 6/11.
[b]Percentage of10 samples per plot on 6/25 - 8/6.

Beetle Sampling The results of sampling in each unreplicated tillage plot, presented in Figures 9 - 11, provided a relative measure of population dynamics. *Coleomegilla maculata* presence was first noted from mid to late July in chisel and conventional plots; beetle presence in the conservation plot was not detected until July 30th. The number of adults increased in chisel and conventional plots and reached their highest population levels of 1.8 and 3.5 adults per 3 m row on the final sampling date. Larval presence in these two plots were first detected in early August. Their numbers increased,

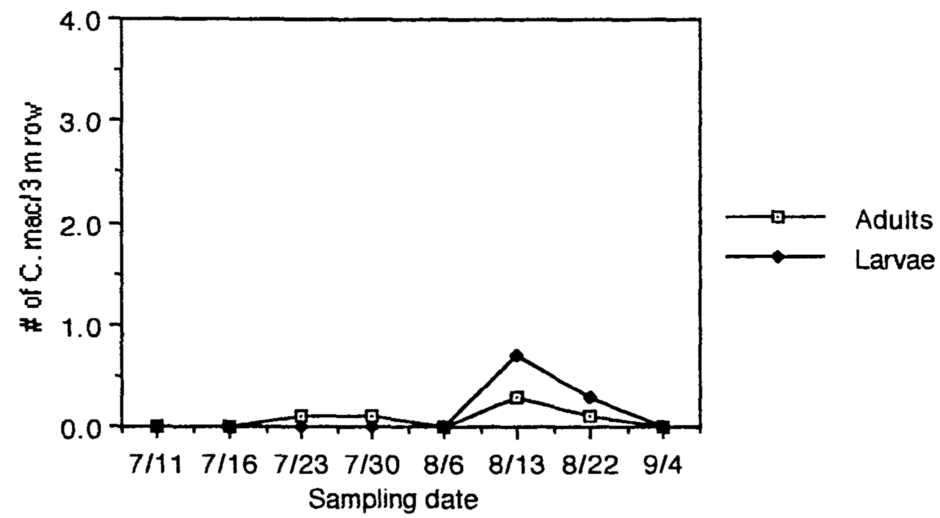


Figure 9. The mean number of coccinellid larvae and adults collected per 3 m row per sampling date in conservation plot

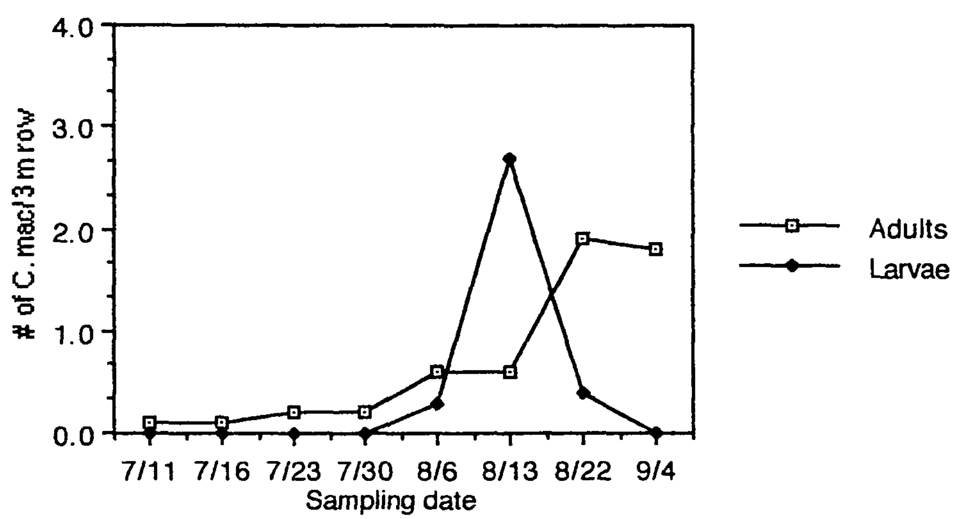


Figure 10. The mean number of coccinellid larvae and adults collected per 3 m row per sampling date in chisel plot

peaked on August 13th (at 2.7 and 1.8 per 3 m row in chisel and conventional plots, respectively), and fell; no larvae were found on September 4th. Larval and adult increases followed a similar trend in the conservation plot, but their combined numbers never exceeded more than 1 beetle per 3 m row.

A total of 172 adults and 71 larvae of *C. maculata* and five *Coccinella septempuctata* adults were captured on eight sampling dates from July 7th to September 4th.

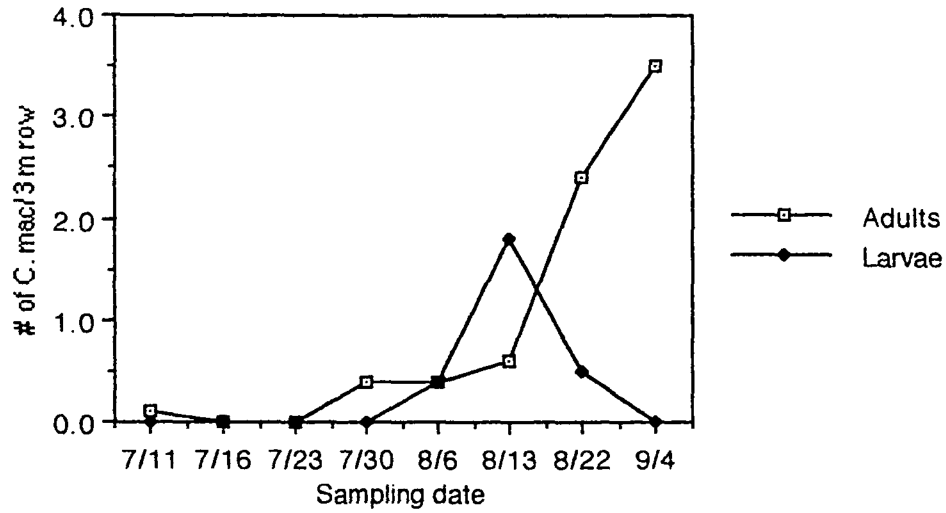


Figure 11. The mean number of coccinellid larvae and adults collected per 3 m row per sampling date in conventional plot

## Discussion

Past research has shown little negative effect of *B. bassiana* on non-target organisms: mortality was low and never exceeded 10% when inoculated by contact (Flexner et al., 1986). But, Magalhaes et al. (1988) found *C. maculata* to be no less susceptible to an isolate of *B. bassiana* ( ARSEF 731) than two target pests when conidia were applied directly to the insects. They concluded that some reduction in the population of *C. maculata* should be anticipated when the isolate 731 is applied and suggested that the search for isolates of *B. bassiana* with a more restricted host range was worthwhile. The results of the present field and laboratory experiments demonstrated no development of mycosis in the*C. maculata* larvae after exposure to the *B. bassiana* isolate, ARSEF 3113; and thus suggested a degree of specificity of the isolate to *O. nubilalis.*

The isolate 3113 is highly virulent to *O. nubilalis* and has provided season-long suppression of the corn pest. Results from foliar applications, when applied in early June initially for its toxic effect on 1st generation *O. nubilalis*, indicated significant reductions in 2nd generation *O. nubilalis* tunneling because of its ability to enter and move within the corn plant (Bing and Lewis, 1991). The isolate did not persist on the outside of the plant throughout the growing season . The present study indicated

*C. maculata* populations did not increase in numbers in the tillage plots until late July to early August. Andow and Risch (1985) reported similar results: the greatest increase in numbers of *C. maculata* corresponded with corn tasseling. These results suggest a spatial and temporal specificity as well--when the beetle is present at its greatest numbers, *B. bassiana* has moved into the corn plant.

Naturally occuring *B. bassiana* was not isolated externally from corn plants for two weeks prior to beetle population increases, however, *B. bassiana* did persist in the soil. Thus, the soil could serve as a continuous source of inoculum for any applied isolate. Due to the habit of *C. maculata* to inhabit the lower parts of the corn plant (Ewert and Chiang, 1966), the possibility exists for *C. maculata* to become contaminated with *B. bassiana* and carry it to the overwintering sites. High rates of infection from *B. bassiana* have been reported in overwintering coccinellids (Hodek, 1973; Mills, 1981). Therefore, more research is needed to determine if the changes in environmental conditions existing in the overewintering sites or in the physiology of the beetle during hibernation could affect the infection of *C. maculata* by the isolate.

There are many factors that could have accounted for the host specificity and lack of disease development of the isolate in *C. maculata* . The review of literature indicated dosage (Champlin et al., 1981), developmental stage of the insect (McCoy et al.,1988), and the length of each stage (Feng et al.,1985) as factors affecting the virulence of *B. bassiana*. The difference in the cuticular composition, specifically the cuticular lipids, between host and nonhost has been found to affect conidial germination and hyphal growth (Saito and Aoki, 1983). Differences amoung isolates related to virulence have been shown: highly pathogenic strains of *B. bassiana* germinated very quickly and directly penetrated the cuticle, while less pathogenic strains took longer to germinate, grew extensively, but failed to penetrate (McCoy et al.,1988). Finally, the abiotic factors--sunlight, moisture, and temperature--can influence spore persistence and germination (Lingg and Donaldson, 1981).

In conclusion, under the conditions of this study, this isolate of *B. bassiana* has shown its compatibility with *C. maculata*. This is very important for *O. nubilalis* management because it suggests that the two beneficial organisms may be used simultaneously in an IPM program.

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## ACKNOWLEDGEMENTS

I would like to express my appreciation to my co-major professors, Dr. Leslie Lewis and Dr. Robert Martin, for their interest, encouragement, and guidance they provided throughout my graduate studies. I want to especially thank them for enabling me through their support to pursue a somewhat unusual thesis project and degree program.

I would also like to thank and recognize the other members of my graduate committee: Dr. Julia Gamon, Dr. John Obrycki, Dr. John Wilson, and Dr. Harold Stockdale.

A special recognition is extended to my mother, Irmgard, and my two aunts, Elsie and Lillie. They have always supported my educational pursuits and life goals.

# APPENDIX A. QUESTIONNAIRE AND CORRESPONDENCE

Iowa State University *of Science and Technology* Ames, Iowa 50011-1050

Department of Agricultural Education and Studies
201 Curtiss Hall
Telephones:
Administration and Graduate Programs 515-294-5904
Research and Extension Programs 515-294-5872
Undergraduate Programs 515-294-6924

Dear Farmer/Grower,

We need your help.

As you are aware, pest control is becoming more problematic. Rising farm costs, fewer chemical pesticide alternatives, and a growing awareness of environmental and health concerns from pesticide use have led to the search for new alternatives for managing crop pests. To develop reliable methods and effective educational programs, we first need to know what you think. Your perceptions--knowledge, attitudes, and impressions--of current pest management alternatives are invaluable to our research.

The responses you provide will be kept strictly confidential. Your individual response will not be identified; results will only be reported in group summary form. Please do not write your name on this form. It has been coded as a means to contact those who have not returned it. When we receive your response, the code number will be removed.

The success of this Master's thesis research depends on your cooperation. We realize you have a busy schedule, but please take 20 minutes to complete and return this questionnaire by April 20. If you do not wish to participate in this study, please return the blank form.

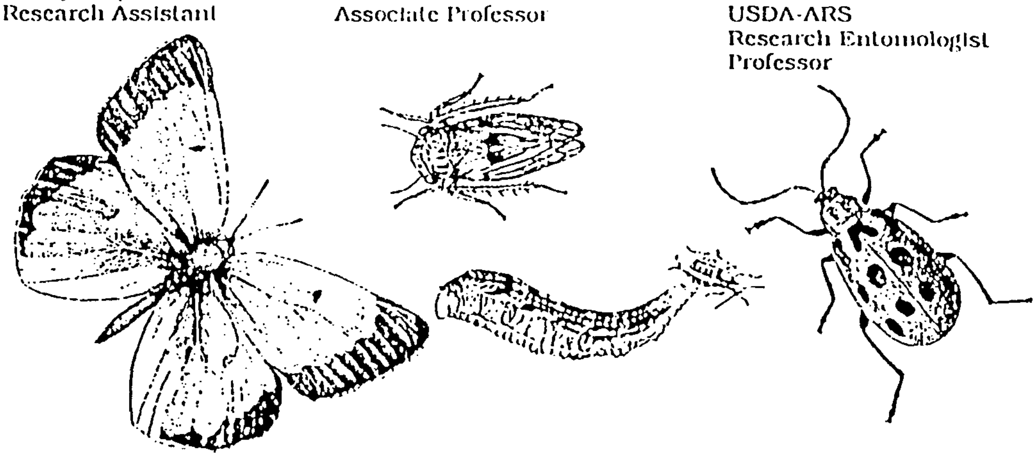
We are deeply interested in getting your opinion about this issue and appreciate your assistance in contributing to this important study. Thank you!

Sincerely,

Randy Pingel
Research Assistant

Dr. Robert A. Martin
Associate Professor

Dr. Leslie C. Lewis
USDA-ARS
Research Entomologist
Professor



# Integrated Pest Management
## A Study of Perceptions

**Instructions**

This questionnaire is divided into four sections. Each section has a brief statement regarding the method of response for that section. Please read each set of instructions carefully.

Section I - General Information

**Please mark the appropriate response with an "x" in the space provided .**

1. Are you familiar with the term "integrated pest management" or "IPM"?

   a. ____yes b. ____no

   Integrated pest management (IPM) is an approach that uses a combination of control methods to manage pests.

2. Have you heard of "biological control" or "biocontrol"?

   a. ____yes b. ____no

   Biological control or biocontrol is a control alternative that uses the natural enemies of pests (parasites, predators, and diseases) to control them.

3. Have you heard of "microbial control"?

   a. ____yes b. ____no

   Microbial control refers specifically to the use of disease-causing microorganisms (viruses, bacteria, fungi, etc.) to control pests.

Section II - Growers perceptions of IPM and biological control

**Please indicate your level of agreement with each of the following statements by circling the appropriate number for each statement. Circle "1" if you strongly agree with the statement and circle "5" if you strongly disagree with the statement. Use the following response categories.**

1 = Strongly agree
2 = Agree
3 = Neutral
4 = Disagree
5 = Strongly disagree

Circle your response

| | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| 1. An alternative pest control method has to be considerably cheaper than pesticides before I would consider its use. | 1 | 2 | 3 | 4 | 5 |

| | | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|---|---|---|---|---|---|---|
| 2. | The use of IPM methods leads to higher variation in yield. | 1 | 2 | 3 | 4 | 5 |
| 3. | IPM methods reduce the risk of crop damage caused by pests. | 1 | 2 | 3 | 4 | 5 |
| 4. | The net returns from IPM use are greater than from conventional control methods (chemical pesticides). | 1 | 2 | 3 | 4 | 5 |
| 5. | The use of IPM methods requires more labor than conventional methods. | 1 | 2 | 3 | 4 | 5 |
| 6. | IPM is a viable alternative for crop protection due to the increased financial gain from its use. | 1 | 2 | 3 | 4 | 5 |
| 7. | There is enough IPM information available to consider its use. | 1 | 2 | 3 | 4 | 5 |
| 8. | The consumer market dictates the pest control alternatives that can be used by growers. | 1 | 2 | 3 | 4 | 5 |
| 9. | Non-chemical control measures are as effective as chemical control. | 1 | 2 | 3 | 4 | 5 |
| 10. | IPM is a new alternative pest control strategy. | 1 | 2 | 3 | 4 | 5 |
| 11. | Killing pests is the major goal of any pest control strategy. | 1 | 2 | 3 | 4 | 5 |
| 12. | It is acceptable to have low levels of crop pests present in the field/orchard. | 1 | 2 | 3 | 4 | 5 |
| 13. | It is always necessary to treat against some insect pest in the field/orchard. | 1 | 2 | 3 | 4 | 5 |
| 14. | The use of pesticides prevents at least 90% of potential loss due to crop pests. | 1 | 2 | 3 | 4 | 5 |

| | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| 15. Pesticide applications reduce the amount of time that has to be devoted to pest control. | 1 | 2 | 3 | 4 | 5 |
| 16. Pesticides are a critical component of IPM programs. | 1 | 2 | 3 | 4 | 5 |
| 17. Protection of the environment is a critical element when deciding whether to spray or not to spray for pests. | 1 | 2 | 3 | 4 | 5 |
| 18. Chemical control provides a means for the individual farmer to control pests independent of the actions of neighbors. | 1 | 2 | 3 | 4 | 5 |
| 19. It is more important to consider the worst possible losses than to consider normal losses when deciding on a pesticide application. | 1 | 2 | 3 | 4 | 5 |
| 20. Chemical control remains the only reliable method for controlling pests. | 1 | 2 | 3 | 4 | 5 |
| 21. Beneficial organisms are able to keep pests at levels so low that no serious crop damage can occur. | 1 | 2 | 3 | 4 | 5 |
| 22. Microbial controls can harm warm-blooded animals (people, cattle, etc.). | 1 | 2 | 3 | 4 | 5 |
| 23. Seeing dead pests tells me that the pest control method I used was effective. | 1 | 2 | 3 | 4 | 5 |
| 24. IPM methods are very complicated to use. | 1 | 2 | 3 | 4 | 5 |
| 25. Increased crop production is my most important farming goal. | 1 | 2 | 3 | 4 | 5 |

Section III - Current Practices

**Please respond to the following questions by placing an "x" in the appropriate blanks.**

1. How many times per year do you check your fields for the presence of insects, weeds, or diseases?

   a. ____Not at all　　c. ____4 to 6 times

   b. ____1 to 3 times　　d. ____More than 6 times

2. Before applying pesticides to your fields, do you systematically scout and then vary treatment based upon problems in different areas?

   a. ___Always　　c. ____Occasionally

   b. ___Sometimes　　d. ____Never

3. In deciding whether to treat your fields with a pesticide, do you systematically sample and compare the infestation levels with established treatment thresholds?

   a. ____Always　　c. ____Occasionally

   b. ____Sometimes　　d. ____Never

4. Which of the following practices do you use as pest control measures? **Please circle the appropriate level for all that apply.**

| | Regularly | Sometimes | Infrequently |
|---|---|---|---|
| a. Tillage | 5 | 3 | 1 |
| b. Pest resistant varieties | 5 | 3 | 1 |
| c. Adjustments in planting time | 5 | 3 | 1 |
| d. Crop rotation | 5 | 3 | 1 |
| e. Chemical pesticide application | 5 | 3 | 1 |
| f. Hire crop consultant to assist in making pest control decisions | 5 | 3 | 1 |
| g. Use microbial insecticides such as Dipel or Thuricide | 5 | 3 | 1 |
| h. Other (Please specify) | | | |
| ______________________________ | 5 | 3 | 1 |
| ______________________________ | 5 | 3 | 1 |
| ______________________________ | 5 | 3 | 1 |

Section IV - Grower Characteristics

**Please respond to the following questions by placing an "x" in the appropriate blanks or by filling in the blank to describe your present characteristics.**

1. Your age is

   a. ____30 years or less    d. ____51 to 60 years

   b. ____31 to 40 years    e. ____61 years or older

   c. ____41 to 50 years

2. How many years have you been farming?

   a. ____10 years or less    c. ____21 to 30 years

   b. ____10 to 20 years    d. ____30 years or more

3. The highest level of education you have completed is

   a. ____Less than high school    c. ____Some college

   b. ____High school graduate    d. ____College graduate

4. How many acres of your current farming operation are in crops? ________

5. How many of these acres are rented? ________

6. What are the major crops produced on your farm? **Please select as many as apply.**

   a. ____basic grains    c. ____forage crops

   b. ____small grains    d. ____vegetables/fruits

7. Do you or your spouse supplement your farm income with work off the farm?

   a. ____yes    b. ____no

**Thank you for your cooperation! Please fold and staple the form so the return address is showing on the outside and return by April 20.**

Iowa State University of Science and Technology Ames, Iowa 50011-1050

Department of Agricultural Education and Studies
201 Curtiss Hall
Telephones:
Administration and Graduate Programs 515-294-5904
Research and Extension Programs 515-294-5872
Undergraduate Programs 515-294-6924

Dear Farmer/Grower,

This is a reminder. About six weeks ago, you received a survey form on pest management. As yet, we do not have your response. We know how easy it is to overlook something like this. At this time, we are sending you an additional copy.

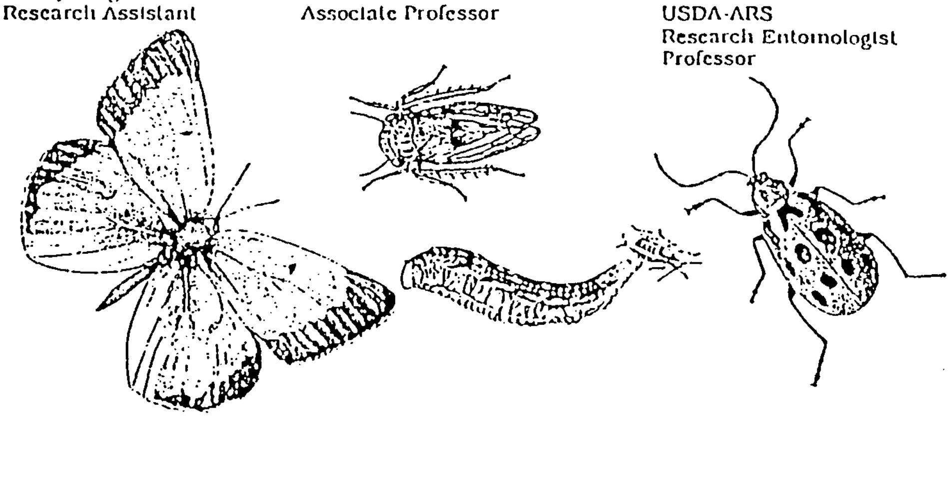
As stated in the first cover letter, the responses you provide will be kept strictly confidential. Your individual response will not be identified, and results will only be reported in group summary form. Please do not write your name on this form.

The success of this Master's thesis research depends on your cooperation. We realize you have a busy schedule, but please take 20 minutes to complete and return this questionnaire by June 10. If you do not wish to participate in this study, please return the blank form.

We are deeply interested in getting your opinion about this issue and appreciate your assistance in contributing to this important study. Thank you!

Sincerely,

| | | |
|---|---|---|
| Randy Pingel | Dr. Robert A. Martin | Dr. Leslie C. Lewis |
| Research Assistant | Associate Professor | USDA-ARS |
| | | Research Entomologist |
| | | Professor |



Dear Farmer/Grower,

This is a reminder. About two weeks ago, you received a survey form on pest management. As yet, we do not have your response. We know how easy it is to overlook something like this in your busy schedule. At this time, we would like to encourage you to complete and return the form. Your opinion is valuable!

Sincerely,

Randy Pingel
Research Assistant

# APPENDIX B. HUMAN SUBJECTS APPROVAL FORM

**Checklist for Attachments and Time Schedule**

**The following are attached (please check):**

12.☐ Letter or written statement to subjects indicating clearly:
- a) purpose of the research
- b) the use of any identifier codes (names, #'s), how they will be used, and when they will be removed (see Item 17)
- c) an estimate of time needed for participation in the research and the place
- d) if applicable, location of the research activity
- e) how you will ensure confidentiality
- f) in a longitudinal study, note when and how you will contact subjects later
- g) participation is voluntary; nonparticipation will not affect evaluations of the subject

13.☐ Consent form (if applicable)

14.☐ Letter of approval for research from cooperating organizations or institutions (if applicable)

15.☐ Data-gathering instruments

16. Anticipated dates for contact with subjects:

First Contact: 3/25/91 (Month / Day / Year)

Last Contact: 6/25/91 (Month / Day / Year)

17. If applicable: anticipated date that identifiers will be removed from completed survey instruments and/or audio or visual tapes will be erased:

5/1/91 (Month / Day / Year)

18. Signature of Departmental Executive Officer — Date: 3/11/91 — Department or Administrative Unit: Agricultural Educ. & Studies.

19. Decision of the University Human Subjects Review Committee:

X Project Approved ___ Project Not Approved ___ No Action Required

Patricia M. Keith — Name of Committee Chairperson — Date: 3/21/91 — Signature